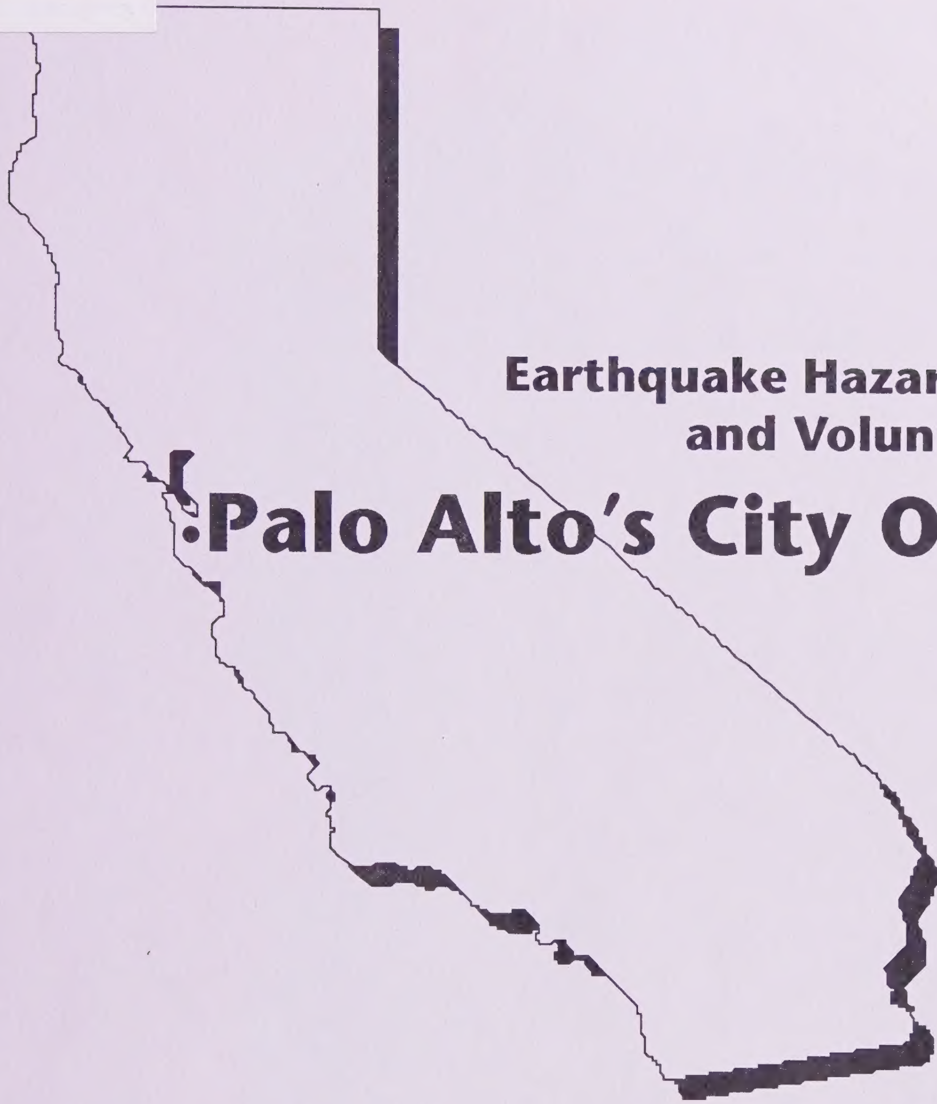

Earthquake Hazard Identification and Voluntary Mitigation:

Palo Alto's City Ordinance

by
Fred Herman
James Russell
Stanley Scott
Roland Sharpe

Palo Alto's unique approach to earthquake hazard mitigation may be applied elsewhere to mitigate hazards not only in unreinforced masonry buildings but in more modern structures...

California Seismic Safety Commission • December 1990 • SSC 90-05

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Foreword

California's Unreinforced Masonry Building Law, passed in 1986, requires cities and counties in the state's most seismically hazardous areas to inventory their unreinforced masonry buildings and to carry out programs to reduce the serious threat that these buildings represent. While the majority of communities covered by this law are working hard to implement it and to reduce their earthquake hazards, many have encountered serious obstacles.

Palo Alto's unique approach to earthquake hazard mitigation may provide insights that can be applied elsewhere. The Seismic Safety Commission hopes that this report – which describes the entire process of developing and implementing Palo Alto's voluntary earthquake hazard mitigation ordinance – may be helpful to other communities struggling with the problem of how to mitigate seismic hazards not only in unreinforced masonry buildings but in more modern structures, especially concrete buildings built before 1973. A voluntary program gives flexibility to try different approaches to seismic strengthening, and in some communities it may be easier to get agreement on such a program.

By requiring disclosure of seismic hazards to building owners, occupants, and public – including, of course, potential buyers, insurers, and lenders – Palo Alto's program allows market pressures to aid in seismic strengthening. It also sets standards for such strengthening, as well as instituting comprehensive evaluation disclosure, reporting, and monitoring requirements. Thus, it is likely to prove far more effective than hazard mitigation programs that stop at notifying owners of unreinforced masonry buildings that their buildings are potentially hazardous.

Ordinances like Palo Alto's, which relies on voluntary action of building owners, aren't the final answer for most California communities. In some communities the economic climate will not be as favorable, and the zoning incentives that Palo Alto offers will not be as effective. Nevertheless, some communities may wish to consider adopting it, at least as an interim program. Such a program can be appropriate in communities where many building owners recognize the earthquake hazard, local economic factors are favorable, and – last but certainly not least – city officials and staff are dedicated to reducing their community's seismic risks.

The Seismic Safety Commission is not making a blanket recommendation for voluntary programs by publishing this report. But we hope that it will encourage everyone affected – local governments, building owners, tenants, and the public – to come to grips with the problems of reducing California's earthquake hazards.

Barbara Cram Riordan, Chairman
Seismic Safety Commission

A Note About the Authors

Fred Herman, James Russell, and Roland Sharpe, who in a staff or advisory capacity were deeply involved in the ordinance's development, provided the main source of information used in preparing this document. They also did much of the writing. Stanley Scott served as editor, coordinator and coauthor.

A few words of identification are in order. Fred Herman, currently the chief building official of Palo Alto, was the principal person in charge of the city's effort throughout the years of study, deliberation, and negotiation. Herman has also been a leader in the work of the California Building Officials (CALBO),and of its research and educational branch, the California Building Codes Institute (CBCI). He is also a member of the Policy Advisory Board of the Bay Area Regional Earthquake Preparedness Project (BAREPP).

Herman was assisted by James E. Russell, a civil engineering consultant retained under a long-term contract to serve as seismic program manager for the city. Russell did much of the research and ordinance drafting, and was one of the principal strategists of the enterprise. He serves as Herman's alternate on the BAREPP Policy Advisory Board and is currently a consultant assisting several northern California cities to develop hazardous building mitigation programs.

Stanley Scott, Research Political Scientist, Institute of Governmental Studies, University of California, Berkeley, and a member and past chair of the California Seismic Safety Commission, has had a long-term interest in the policy aspects of seismic safety and earthquake engineering, and has written extensively on those subjects. He is also a member and past chair of the BAREPP Policy Advisory Board.

Roland Sharpe, a Palo Alto structural engineer and representative of the Structural Engineers Association of Northern California (SEAONC), was a member of the citizens' committee appointed to review the entire matter after the first ordinance draft met determined opposition. He participated throughout the lengthy deliberations during which the committee eventually worked out an acceptable ordinance. In addition, he assisted Russell in developing structural investigation standards for the ordinance. Sharpe has been active in seismic code development nationally and in California. He has also been active in the seismology committee of the Structural Engineers Association of California (SEAOC), the Applied Technology Council (ATC), and the Building Seismic Safety Council (BSSC). He is currently a member of the Advisory Committee to the National Earthquake Hazards Reduction Program.

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Authors' Preface

This report examines the background and development of Palo Alto's unique approach to earthquake-hazard reduction in its private-sector building stock. While recognizing the great importance of earlier groundbreaking hazardous building mitigation efforts by other California cities such as Long Beach, Los Angeles, Santa Rosa, and Santa Monica, we believe that the Palo Alto approach is an innovation that may be helpful for other communities in California and elsewhere. Many readers may find valuable guidance from the events and processes that gave rise to Palo Alto's voluntary hazard abatement ordinance.

The difficulties, challenges and opportunities of earthquake hazard reduction in other parts of the United States potentially at risk resemble those in California, although they also differ in significant ways. Our treatment of Palo Alto's processes for choosing the kinds of hazardous buildings to identify and investigate, and deciding on the kind of program that could reasonably be attempted, should be of considerable interest in parts of the nation where activity on such issues is in progress.

The projected audience for this report is broad, including those in and outside of government who currently have a stake in resolving the economic, social, and policy issues in hazard reduction. Local and state officials concerned with public safety, redevelopment, community planning and zoning, and emergency preparedness are a few of those who must sooner or later deal with this subject. In addition, we also believe this report can help private-sector owners of potentially hazardous buildings, as well as elected decision-makers in communities where earthquake hazards have reached the active political agenda.

Finally, the growing community of "earthquake-preparedness activists" in California and elsewhere may get useful ideas for adaptation and implementation in their own localities. Beyond this, students and observers of local government should also find Palo Alto's experience a valuable case study of one city's approach to a seemingly intractable problem. It describes the staff work, policy exploration, negotiation and compromise involved in successfully enacting Palo Alto's program and beginning its implementation.

Local hazard reduction ordinances like Palo Alto's can enable some cities to make starts in the difficult business of hazard mitigation. Such ordinances (1) publicly identify types of buildings believed potentially hazardous, and (2) through investigation, obtain detailed new information on the actual resistance of individual structures.

Palo Alto's ordinance includes structures of a wide range of types and ages, in addition to the unreinforced masonry structures (URM buildings) typically covered. This is a very significant departure from many if not most other local hazard reduction programs in California. Palo Alto's program thus acknowledges that many types of buildings other than URM buildings can pose serious life and safety threats. Formulas like Palo Alto's may be good ways to initiate the next phases of California's hazard review effort–going beyond URM buildings to other potentially hazardous structures, which most urban areas have in large numbers.

Under a voluntary ordinance, some willing owners, and even some reluctant owners, are likely within a reasonable time to initiate remedial action by strengthening their buildings, changing the use or occupancy, replacing structures altogether, or disposing of them by selling to new owners who may have plans for rehabilitation or replacement. If a voluntary ordinance stimulates a significant amount of remedial activity, a community's overall seismic hazard can be appreciably reduced.

In addition to its direct effects of encouraging mitigation of hazards in designated buildings, important indirect or "ripple" effects of such a program may assist materially to encourage mitigation

of other seismic hazards by raising the awareness of the community as a whole. The promotion and encouragement of seismic hazard reduction efforts by those not included in the ordinance was made possible in part by the city council's endorsement of this program. In sum, ordinances like Palo Alto's, while falling short of the stringency of mandatory hazard mitigation, may nevertheless result in a good deal of hazard reduction.

Admittedly, of course, voluntary ordinances like Palo Alto's have their limitations. The ordinance was tailor–made for Palo Alto, which is blessed with several favorable characteristics that facilitated success. Other communities in different circumstances and lacking several of these factors may find this approach neither adequate nor effective in reducing hazards. Under voluntary ordinances some or perhaps many owners may simply be unwilling to act, or consider themselves financially unable to strengthen their buildings. Consequently a formula for hazard reduction based on Palo Alto's may not work very well in some communities.

Moreover even those communities that are able to enact such ordinances and make appreciable progress are likely eventually to need something stronger than a voluntary program, e.g., a mandatory ordinance, or state action mandating retrofitting, or some combination of triggering mechanisms, incentives, and penalties.

In the wake of the 1989 Loma Prieta earthquake some cities in northern California have adopted nearly identical versions of the Palo Alto ordinance, but have limited the scope to URM buildings. In due course the effectiveness of this approach in those communities will need to be reviewed and evaluated, adding to our base of knowledge about what formulas work and under what circumstances.

In conclusion, in the next few years much is likely to be learned in communities throughout the state that have adopted some form of active mitigation ordinance, both mandatory and voluntary. The knowledge gained should help with the development of new approaches where existing ordinances fall short. This can promote progress on the long road to reasonable security against earthquake hazards. Palo Alto's experience should contribute significantly.

Fred Herman
James Russell
Stanley Scott
Roland Sharpe
June 12, 1990

Introduction

In January 1986, Palo Alto adopted an earthquake hazard mitigation ordinance titled "Seismic Hazards Identification Program." The program's broad coverage of building types and ages, combined with its unorthodox approach to hazard reduction, placed it apart from the ordinances adopted in 30 other California jurisdictions prior to July, 1989. In developing the Palo Alto ordinance, the pioneering efforts and different strategies of earthquake hazard mitigation in the cities of Long Beach, Los Angeles, and Santa Rosa were considered, but the primary reason for the uniqueness of the final ordinance is the work of a committee of citizens who were charged by the city council to develop "a practical, cost effective approach" that could work in Palo Alto. The committee's recommendation resulted in the city requiring investigation of 92 buildings suspected of having potential hazards. But Palo Alto stopped short of requiring repairs in the usual regulatory fashion that other local governments have used.

Instead, the intent of the Palo Alto ordinance is to identify hazardous buildings and, through public disclosure of information on the hazards discovered, to encourage owners to correct these deficiencies voluntarily. The process begins by requiring a detailed engineering evaluation report that identifies existing structural deficiencies, evaluates the potential for collapse or partial collapse, and suggests appropriate repairs. These reports, submitted to the city under a defined schedule, are prepared by a civil or structural engineer employed by the building owner, and become public records. Owners of buildings whose reports indicate a potential for collapse must submit a letter within a year stating their intentions regarding remedial repairs. Beyond that, further action is left to each owner's initiative.

The disclosure of information on serious structural problems that could result in life loss or injury in an earthquake is intended to provide a number of incentives for affected owners to take corrective measures. The concept of relying on voluntary action was difficult for Palo Alto's city building official to accept, but the citizens' committee believed that the economic and liability impacts of disclosure would bring results. Moreover, the voluntary approach permitted a flexibility in the scheduling of owner action that is not available under the mandatory repair programs of other cities. Palo Alto also added an incentive for owners of downtown buildings by allowing the addition of floor area without providing equivalent parking in those buildings that are seismically strengthened.

In scope, the ordinance includes unreinforced masonry buildings as one category, and those of other types of construction materials in two additional categories classified by the number of occupants and the original date of construction. Expanding on the examples of Long Beach and Santa Rosa, where unreinforced masonry buildings are not the only structures considered potentially hazardous, Palo Alto targeted for investigation buildings containing 300 or more occupants constructed prior to August 1976, and those with over 100 occupants built prior to 1935. This coverage is similar to that contemplated in California Senate Preprint Bill No. 1 (Alquist), the High Occupancy Building Seismic Safety Act, introduced in January 1989. The bill, which was reintroduced, amended and renumbered as SB5X in the 1989 extraordinary legislative session, would require the structural evaluation of all buildings containing more than 200 occupants every 25 years. When SB5X died, a similar bill, SB 2320, was introduced by Senator Alquist in February 1990, but it too died on the Senate Floor in June of 1990.

Although Palo Alto's program was developed before the enactment of SB 547, the Unreinforced Masonry Building

Law[1], the ordinance placed the city in compliance with the law's requirement for a mitigation program aimed at reducing the hazards of unreinforced masonry (URM) buildings. With over 300 California jurisdictions implementing SB 547, alternative approaches like Palo Alto's may be of considerable interest to many local officials and seismic safety policymakers.

This report describes the ordinance in detail and discusses the main events in its development and adoption. Topics covered include background on the measure's origin, the concept of voluntary action, the political and economic hurdles faced by the citizens' committee, and the methods used to overcome them. In addition, key documents used by the committee are excerpted or referenced. Finally, results of the early phases of the program's implementation are summarized.

The Ordinance Summarized

The Palo Alto ordinance requires 92 privately and publicly owned buildings to be investigated and evaluated for structural deficiencies that could cause a partial or total collapse in an earthquake. (See Exhibit 6 for the text of the ordinance.) The city notifies each owner of an affected building that a report on the building's seismic resistance is due within a specific time period. Each report must be prepared by a civil or structural engineer and must: (1) evaluate all the building's structural elements used to resist earthquake forces; (2) analyze the present capacity of those items to resist a specific required level of force; (3) quantify the level of deficiency, if any, in each element relative to the required level of force; (4) evaluate the overall implications of the deficiencies with respect to their potential for causing a partial or total collapse; and (5) recommend specific strengthening measures to correct the deficiencies.

Before it is finally accepted, each report is subject to review by an engineer employed by the city. The reviewing engineer checks the report for compliance with the technical requirements of the ordinance, and determines whether the conclusions regarding collapse potential and recommended strengthening are consistent with the evidence presented. Inadequate documentation of investigations of a building's present structural adequacy, or unclear statements about the collapse potential, are grounds for rejecting a report.

The ordinance designates three building categories for attention, in order of priority. The first priority (Category I) comprises all unreinforced masonry buildings, including bearing-wall type buildings and those with concrete or steel frames and unreinforced masonry (URM) infill walls, except those of less than 1,900 square feet and fewer than seven occupants. The second priority (Category II) comprises all buildings with 100 or more occupants constructed before 1935. Category III includes all buildings containing 300 or more occupants constructed before August 1976, which is the date Palo Alto adopted the 1973 edition of the Uniform Building Code.

Under the ordinance procedure the city first sends a notice to each affected property owner, who is required to respond with a report—as discussed above – according to the following schedule:

Category I Buildings (URM)	18 months
Category II Buildings (pre-1935)	24 months
Category III Buildings (pre-1976)	30 months

The time periods shown began on May 11, 1986, the date notices were sent to owners. The only exception to the above schedule was that notices to owners of historic buildings were delayed by an 18-month time extension.

Two sets of structural standards, found in the ordinance's appendices, were established. Appendix A applies to all buildings *except* unreinforced masonry bearing-wall buildings. It includes instructions to the engineer conducting the study, prescribing the items to be field-investigated, analyzed, evaluated, and reported on. It requires a comparison between: (1) the minimum demand

[1] The Unreinforced Masonry Building Law, enacted in 1986, requires all cities and counties within the most earthquake-prone regions of California to inventory and establish hazard mitigation programs for "potentially hazardous buildings" defined as those containing unreinforced masonry walls constructed prior to the adoption of earthquake design standards (Section 8875 et seq of the Government Code).

for earthquake force resistance that the 1973 Uniform Building Code (UBC) would require, and (2) the existing capacity of each structural element to resist those forces. In addition to this quantitative analysis and comparison, specific items not prescribed in the UBC must also be qualitatively assessed, e.g., the degree of building deterioration and the structural system's redundancy and inherent ductility (i.e., the ability to absorb earthquake energy without collapse). The effects of building geometry, adjoining structures, nonstructural elements and site geology must also be considered.

Appendix B provides standards for evaluating URM bearing-wall buildings. These were adapted from the chapter of the 1985 Uniform Code for Building Conservation (UCBC) dealing with the repair of URM buildings. The UCBC, adopted by the International Conference of Building Officials, was modified for application in Palo Alto's procedure, which requires only investigation and analysis and does not specify a method of repair.

Though Palo Alto does not require an owner to repair a building found deficient, its ordinance does require two actions after completion of the engineering report. First, within thirty days of submitting the report to the city, the owners must give the tenants a written notice that a report containing the structural evaluation has been performed and is available at the city building inspection offices. Second, within one year of report submittal, the city must receive a letter describing the owner's intentions for dealing with any potential collapse hazards found.

As the program progresses, the building official is required to report to the city council twice a year on the number of buildings analyzed, the severity of structural inadequacies discovered, and any actions taken by owners to strengthen their buildings.

At about the same time the ordinance was passed, Palo Alto made two other seismically related code changes. Both were based on ideas endorsed by the citizen's committee, but were placed in the building code rather than the ordinance for enforcement purposes. The first change relates to major remodeling of an existing building, defined as repairs or improvements within any 12-month period that exceed 50 percent of the replacement value of the structure. If this threshold is reached, the structure must comply with the city's currently adopted edition of the UBC for lateral forces. (A similar provision was in the 1976 and earlier editions of the UBC, but has since been removed.) The second change requires the bracing of suspended ceilings, including light fixtures, in any building area that is remodeled. This regulation provided excellent results during the Loma Prieta Earthquake.

A Voluntary Repair Program

The voluntary character of Palo Alto's repair program makes it a significant experiment in promoting hazard mitigation. While identification of deficiencies is mandatory, remedial action is voluntary. The voluntary feature may have made it possible for Palo Alto to cover more types and ages of structures than other jurisdictions, which have tended to focus almost exclusively on unreinforced masonry buildings.

Some critics of the voluntary approach concluded, however, that without mandating structural rehabilitation and exercising the city's police powers, the measure would not produce significant results. They believed that owners could not be expected to act without more incentive than information in an engineer's report, and that some method of enforcement would also prove necessary to stimulate action, even though some owners had given assurances that they would indeed make necessary improvements under a voluntary system during public hearings on early ordinance versions that mandated repairs.

Santa Monica was the only other California city to experiment with a voluntary program during this period, having tried an interesting combination of voluntary and mandatory measures. Santa Monica's effort started in 1978 when the city placed notices on the deeds of its approximately 240 URM buildings stating that buildings did not meet the requirements of the 1933 Riley Act (state legislation that required earthquake resistant design in buildings).

Santa Monica went to this method after a proposal for a mandatory repair ordinance was rejected by the city council. It was hoped that inclusion of the information on property title documents would encourage owners to repair their buildings, or at least would inform future buyers about the potential hazard, and the action did result in the strengthening of 50 buildings, representing nearly one-third of the total floor area of Santa Monica's URM buildings. These repairs brought the buildings up to the *final* level of strengthening required by the Los Angeles city seismic rehabilitation program.

In 1980 Santa Monica took the further step of *requiring* wall anchor installations similar to the *first*-stage repairs under the Los Angeles city approach. These mandated repairs have been completed for all affected buildings.

In December 1988, after a full decade of effort under these voluntary/ mandatory measures, Santa Monica decided to pursue a more vigorous program of mandatory repair. The city was motivated by damage in the 1987 Whittier earthquake, by passage of the California's URM Building Law (SB 547), and by the lack of voluntary action by the owners of those buildings that remain unstrengthened except for wall anchor installation.

An ordinance requiring a seismic evaluation report by a licensed structural engineer on all URM buildings was adopted by Santa Monica in July of 1989. No specific seismic safety standard is specified, although the report may include recommendations to "improve the level of seismic performance of the structure to any percent gravity above the state's 1933 Riley Act minimum standards or two percent of the building's total vertical design load." In contrast, Palo Alto uses 10 or 13 percent of dead loads for its analysis of URM buildings, depending on the number of occupants.

The success of Palo Alto's ordinance will depend largely on how effectively the program motivates owners to strengthen deficient buildings. Full public disclosure of the information obtained is an important element of the approach. Tenant notification and public availability of the information may have a significant influence on many—indeed, some owners actually began strengthening their buildings prior to the dates when their engineering evaluation reports were due. The building official allowed such action in lieu of a report, since the intent of the ordinance namely the strengthening of buildings, was being met.

Knowledge of seismic deficiencies, along with California's public disclosure law covering real estate transactions, is likely to affect resale or rental values, eligibility for refinancing, and the cost of purchasing earthquake risk insurance. These economic effects, and the potential for future liability in case of earthquake-caused injury or loss of life, were factors in the recommendation of a voluntary repair program. (See Exhibit 5 for the text of the committee's final report.)

The threat of stronger measures may also persuade some owners to take action on deficient buildings. At the time of the council's final action on the ordinance, there seemed to be a tacit agreement that its progress should be reviewed after a few years in the light of evidence, such as the owners' letters of intent and building official progress reports to the city council on the voluntary response.

Shortly after the hazards identification ordinance was passed, the city added an owner incentive by modifying the zoning laws governing floor space expansion and parking requirements in the downtown area to permit expansion of the floor area of downtown buildings included in the program if the owner performs the necessary seismic strengthening. In the early 1980s, when downtown Palo Alto was in the midst of a construction boom, the city council placed a moratorium on building downtown. When the moratorium expired, new controls limited floor area and required on-site parking, which virtually eliminated the possibility of new buildings or additions to existing buildings.

However, an owner who strengthens his building can add 2,500 square feet or 25 percent of the existing usable floor area, whichever is greater, up to a maximum zoning floor area ratio of 3:1. Moreover, this expansion is exempt from on-site parking requirements, thus removing the prospect of installing costly underground parking.

Origins of Palo Alto's program can be traced to the seismic safety element of the city's comprehensive planning document, adopted in 1976. After the San Fernando earthquake of February 1971, the state's land use planning requirements were changed to mandate that all local plans include seismic safety elements. In suggesting the scope of such elements, in 1973 the California Council on Intergovernmental Relations issued guidelines that included "consideration of existing structural hazards...." and suggested "building inspection programs to identify unsafe structures and instigate necessary corrective measures....."[2]

The 1976 Seismic Safety Element

Palo Alto's seismic safety element included this charge:

> The city should contract with a structural engineer to inspect and evaluate all high occupancy buildings and all buildings more than two stories. City codes should also be reviewed to ensure correction of public safety deficiencies.

Elizabeth Crowder,[3] author of this passage and at the time a planner on the city's staff, had a keen interest in geology and earthquake safety. In 1975 she had drafted a 23-page background report, including a specially prepared geologic map, identifying the geologic hazards in the area and suggesting ways for the city to minimize seismic dangers to its citizens. The report went beyond a narrow interpretation of what is

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[2] California Council on Intergovernmental Relations, "Guidelines for the General Plan Elements: Seismic Safety." *General Plan Guidelines* (Sacramento: September 1979), pp. IV-23 to IV-28.

[3] The work of Elizabeth Crowder and her late husband is significant enough to merit an additional note of explanation. George Mader and others have documented the remarkable role of Dwight Crowder, a geologist with the U.S. Geological Survey, in successfully pressing for recognition of the importance of geology in local community planning. Before his untimely death in 1970 at age 40, Dwight Crowder's efforts had been instrumental in securing adoption by Portola Valley of ordinances and local policies taking geologic factors into account in zoning, subdivision, and site development decisions. See Mader, George G., and others, *Geology and Planning: The Portola Valley Experience*, Portola Valley, CA, William Spangle and Associates, 1988.

In dedicating their study to the memory of Dwight Crowder, Mader and colleagues comment: "He was an unusual blend of geologist, activist, and compassionate human being. As a geologist, he perceived the importance of the geology to the future development of the town; as an activist, he was willing to engage in the give and take of local politics; and as a compassionate human being, he was able to inspire the action of others...the town's program stands today as a testimony to his contributions."

After Dwight Crowder's death, Elizabeth Crowder went back to college, educated herself in planning and environmental subjects, and joined the staff of the City of Palo Alto. In this capacity she in her turn played a very significant if somewhat behind-the-scenes role in laying crucial groundwork for Palo Alto's forward-looking effort to deal with seismically hazardous buildings. These accomplishments of Elizabeth and Dwight Crowder are excellent illustrations of something observed in other studies of earthquake policy development: the fact that persistent, thoughtful work by a few dedicated individuals can have a major influence.

"geologic" or "seismic" by discussing a wide range of safety hazards, including earthquake-caused building collapse, lifeline damage, communication and transportation disruption, and fire or explosion risks.

The upshot was that Palo Alto adopted a more inclusive element and used stronger language than is typical of the local plans of most jurisdictions. Most local plans include geologic and seismologic information in the context of physical and environmental land use, but do not stress the crucial effect of ground shaking on structures. By specifically emphasizing existing building hazards and recommending remedial action, the Palo Alto element helped set the stage for the city's action on seismic hazard reduction programs prior to the passage of SB 547.

Economic and Social Factors

Other factors probably contributed to the ability to move ahead with a hazardous-buildings ordinance. Palo Alto is an affluent community, and downtown projects are usually profitable. More economic wherewithal is available to finance rehabilitation than would be found in nonaffluent or decaying central areas. Moreover, the premium on downtown space increased the attractiveness of the ordinance's floor space expansion incentive.

No-growth or slow-growth sentiment is popular in Palo Alto, home of Stanford University and well-known for its "progressive political environment." Evidence from recent research on the ordinance funded by the National Science Foundation suggests a connection between support for seismic rehabilitation and the slow-growth attitudes that lay behind the moratorium on downtown expansion.

The researchers also found Palo Alto's officials to have a strong sense of public responsibility, commenting: "Such attitudes...of elected officials must be seen to be, at least in part, a function of highly-educated, civic-minded community."[4]

Budgeting Funds for the Program

The process of carrying out the Palo Alto seismic safety element's charge began with a budget request from the city planning department for $10,000 in capital improvement project funds. These funds were approved, but the Division of Building Inspection Services (DIS hereafter) took no action because it lacked the necessary personnel. About two years later, DIS was transferred from the public works department to the planning department, where the project was given a higher priority because implementation of this part of the city's comprehensive plan was seen as a planning department issue.

At this point the DIS, under the direction of the chief building official, Fred Herman, began to consider what additional resources it would need to implement the proposed program. The initial $10,000 was wholly inadequate. A request for an additional $50,000 in the 1980-81 budget proposal was approved despite a lack of documentation, primarily because the director of planning was influential in the budget process.

In 1981, DIS conducted research to determine the number of buildings potentially involved, and discussed the cost of contracting for evaluating approximately 250 buildings with a number of consulting structural engineers. The results indicated that still more funding would be needed for meaningful inspection and evaluation of the buildings covered by the seismic safety element.

DIS's request for an additional $55,000, for a total of $115,000, to begin the program met considerable resistance during staff budget review, primarily because none of the funds previously budgeted had been used, but additional cost documentation and strong support from the determined planning director, Naphtali Knox, overcame the objections of the majority of the staff budget committee members.

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[4] Timothy Beatley and Philip Berke, "Seismic Safety Through Public Incentives: The Palo Alto Seismic Hazard Identification Program," Earthquake Spectra, Vol. 6, No. 1, February 1990, pp. 57-79.

The First Draft

The process of drafting an ordinance was begun in December 1981, when consultant James Russell was hired to manage the program. His first steps included a review of local seismic hazard programs in other jurisdictions and of relevant state and federal legislation. Special attention was given to the two cities of Santa Rosa and Long Beach, the only jurisdictions whose programs then went beyond repair of unreinforced masonry (URM) buildings.

Santa Rosa had responded to its damaging 1969 earthquake with an effective program that included other structural types in addition to URM. It also included buildings constructed up to 1957 rather than using a 1930s cutoff date, as has been more typical of other local buildings programs. Although the Long Beach program begun in 1959 deals only with pre-1934 buildings, it, too, extends beyond URM construction.

The impact of these examples, and of the affirmative language of Palo Alto's seismic safety element, was reinforced by the consultant's conviction that the city's seismic building problem extended well beyond URM structures. Consequently he drafted the first ordinance to include not only URM buildings, but also those with more than 100 occupants and constructed as recently as 1965, as well as structures over two stories in height.

The building official and the consultant knew that mandatory repair requirements would have substantial economic impacts on many building owners and were uncertain as to the strength of the council's political resolve to address the hazardous buildings issue. Thus, the initial draft of the ordinance was less a serious attempt at a workable ordinance than a trial balloon to test the council's support.

An Adverse Response

In March 1982, the first of several draft ordinances got a public hearing before the council's Policy and Procedures Committee, comprising four of the council's nine members. This version called for the investigation of 250 buildings in four years, *and* for the repair of those found deficient to bring them up to the seismic resistance standards of the 1964 Uniform Building Code.[5]

The hearing drew a strong response, including overwhelming attendance at the council committee meeting, mostly of owners who had been notified that their buildings came within the scope of the proposal. After hearing 24 speakers against the draft ordinance, the committee sent a disapproval recommendation to the full council, which was to hear the matter the following month.

Call for a Citizens' Committee

At the council meeting in April 1982 the committee's disapproval was affirmed, and there was considerable criticism of the city staff's procedure in developing a proposal without discussions with the affected members of the community. The council directed staff to "establish a citizens' committee to recommend an economical, practical, and cost-effective method of reducing seismic hazards in Palo Alto." This made clear both the council's concern with seismic safety and its desire to seek a compromise solution with a reduced adverse impact. Indeed, in calling for a citizens' committee to make a formal recommendation on the subject, the council virtually assured the development of some kind of program, and opened the door for the citizens' committee to produce a mitigation strategy that the council and the building owners would in due course accept.

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[5] The 1964 edition of the Uniform Building Code was chosen with the sole purpose of having a date earlier than the building construction cutoff date of 1965. It was not chosen for its seismic force determination content, nor its recognition of current failure mechanisms, and would not be recommended for use in performing investigation and analyses, nor for a reconstruction standard.

The Citizens' Committee at Work

The formation of the citizens' committee took several months. The planning director suggested several organizations that should be represented, including the Chamber of Commerce, the Board of Realtors, the Downtown Merchants Association, Downtown Palo Alto Inc., the California Avenue Area District Association, and the city's Planning Commission, Architectural Review Board, and Historic Resources Board. The building official and consultant requested that they serve as ex-officio members and provide staff support, and that at least two structural engineers and an architect be included.

Thus, the committee membership was quite diverse, ranging from a building contractor and a building owner to engineers, architects, owners of small businesses who were there as tenants, and a former mayor whose main offices were located in a building identified as being constructed of unreinforced masonry. Several members were opponents who had spoken at the March council committee meeting. Some supported the concept of seismic safety, but only if its application would not affect them in a direct economic way, or if it did not threaten the preservation of historic buildings.

The role of chair was accepted by an architect, John Northway, who was at the time a city planning commissioner and former chair of the city's Architectural Review Board. His leadership abilities were to have a profound effect on the committee's progress during its nearly 15 months of meetings.

Getting Started

The committee's entire effort can be seen as a valuable learning process. It covered the major issues that nearly every local government must consider and resolve in deciding on an acceptable hazardous building mitigation strategy.

To begin the process, the city staff outlined a proposed sequence of activities and responsibilities:

- The citizen's committee would develop the policies to be included in the ordinance.
- The city staff would then draft the ordinance.
- The committee would consider the draft and approve or modify it.
- The Policy and Procedures Committee of the City Council would review the ordinance and send it to the full council with a recommendation of approval, approval with modification, or disapproval.
- The council would review the proposed ordinance, hear from the public, perhaps make modifications, and either approve or disapprove the final version.

Basic Issues and Related Topics

At its first meetings the committee outlined a number of basic issues to be examined at length:

- Criteria for building identification.
- Time schedule for implementation.
- Assessing possible economic impact.
- Practical incentives to strengthen buildings.
- Restrictions on ownership transfer.
- Preventing loss of low-income housing.
- Assessing the probability and severity of damage.
- Legal ramifications; liability exposure of: (1) committee members, (2) owners, and (3) the city.

In addition, the committee identified other related topics and information to be reviewed:

- The potential use of a subcommittee system to analyze the basic issues,

establish goals, and develop a schedule for the committee's work.

- The seismic hazard programs in other cities (to avoid unnecessary duplication of effort in developing the technical details of a Palo Alto ordinance).
- Information regarding the dynamics of earthquake forces acting on buildings, for the benefit of non-engineer members.
- Survivability of building occupants and possible rescue of victims after an earthquake.
- The extent to which an ordinance might deal with property damage control in addition to life safety concerns.
- The possibility of using building vacancy as a triggering mechanism for initiating structural repairs.
- Economic and legal incentives that might assist building owners or tenants in complying with requirements for structural rehabilitation.

Informational Briefings

Much of the information requested was developed and presented by city staff and the consultant. Presentations were also made by committee members, as well as by outside professionals.

In preparing to consider and develop an ordinance, committee members wanted to understand the kinds of damage that should be expected, as well as the other possible consequences of earthquakes. Reports on possible casualties were reviewed.[6,7] Information on past earthquakes was presented, including deaths and injuries from

FIGURE 1

Relation Between Earthquake Intensity and Ground Shaking

Modified-Mercalli Intensity Scale		Ground Acceleration g=gravity
I	Detected only by sensitive instruments	
II	Felt by a few persons at rest, especially on upper floors; delicate suspended objects may swing.	
III	Felt noticeably indoors, but not always recognized as a quake; standing autos rock slightly, vibration like passing truck.	005g
IV	Felt indoors by many, outdoors by a few; at night some awaken; dished, windows, doors disturbed; motor cars rock noticeably.	.01g
V	Felt by most people; some breakage of dishes, windows and plaster; disturbance of tall objects.	
VI	Felt by all; many frightened and run outdoors; falling plaster and chimneys; damage small	.05g
VII	Everybody runs outdoors; damage to buildings varies, depending on quality of construction; noticed by drivers of autos.	0.1g
VIII	Panel walls thrown out of frames; fall of walls, monuments, chimneys; sand and mud ejected; drivers of autos disturbed.	
IX	Buildings shifted off foundations, cracked, thrown out of plumb; ground cracked; underground pipes broken.	0.5g
X	Most masonry and frame structures destroyed; ground cracked; rails bent; landslides.	1g
XI	New structures remain standing; bridges destroyed; fissures in ground; pipes broken; landslides; rails bent.	
XII	Damage total; waves seen on ground surface; lines of sight and level distorted; objects thrown up into air.	5g

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[6]Bolt, Bruce A., and Richard H. Jahns, "California's Earthquake Hazard: A Reassessment," Public Affairs Report vol. 20, August 1979, no. 4, Institute of Governmental Studies, University of California, Berkeley.

[7]San Mateo County, Seismic Safety Element, pp. 1653-55.

building collapse, falling exterior appendages, and failure of interior improvements. The Committee was also briefed on how earthquake motions are propagated, and on the relationship of various levels of ground shaking intensity to building damage (See Figure 1).

A comparison of ordinances in other California cities was prepared by the consultant for committee discussion, covering Santa Rosa, Long Beach, Los Angeles, and Santa Ana. (See Table 1). The discussion dealt with the code basis for the lateral force levels used; time schedules for rehabilitation; total number of buildings involved; criteria for classification of buildings (e.g., building types, size, or age); number of risk categories; hazard assessment methods; and criteria for rating structural deficiencies.

The committee took a particular interest in the probable cost of upgrading buildings. Estimates based on published studies were augmented by data from a survey conducted by the consultant of Los Angeles building owners who had repaired URM buildings. The structural engineer members of the committee relied on their own experience to make cost estimates for other types of structures. The committee would have liked to have been able to estimate the total cost of upgrading all hazardous buildings in Palo Alto but this figure could not be estimated until the number of truly hazardous buildings had been determined.

Concern was expressed as to whether committee members might incur potential legal liabilities if an earthquake occurred while the ordinance was being developed. Possible liabilities of building owners were also discussed. Asked to report on both issues, the city attorney confirmed that committee members would not have any liability, but that owners might if they had knowledge of a deficient condition.

Nevertheless the committee believed that the costs of requiring seismic repairs would have a serious financial effect on owners, and the staff outlined possible measures to mitigate this impact (Exhibit 1) and provide financial assistance (Exhibit 2). Although many of these measures were not feasible, the attention given them demonstrates the breadth of the committee's discussion and study effort.[8]

Evaluating Seismic Hazard

After approximately three months of preliminary briefing, the citizens' committee began separating the components of seismic hazard into (1) building collapse, (2) falling hazards of external appendages that would endanger pedestrians, and (3) internal nonstructural hazards that would endanger occupants. It was felt that full compliance with the council's charge required consideration of all aspects of seismic hazard to be included. The third concern was eventually addressed by amending the city building code rather than including it in the ordinance.

The introduction of a new ordinance draft that contained all three aspects of earthquake hazard sparked some five months of debate on methods of ranking hazards and types of building construction, and on ways to establish a fair and equitable system and timetable for requiring repairs. Several meetings were devoted to criteria for identifying dangerous buildings. The committee

[8] Since Palo Alto's work on this subject, many new sources of information and guidance have become available to help those who are studying the fiscal and economic aspects of seismic rehabilitation. Moreover, experience with several seismic retrofit programs, as well as research by federal, state and local agencies, is shedding more light on the social implications of hazard reduction. These critical issues deserve careful attention when ordinances are being considered. Advice on the best information sources currently available should be sought from the California Seismic Safety Commission (1900 K St., Suite 100, Sacramento, CA 95814, (916) 322-4917); the Bay Area Regional Earthquake Preparedness Project (MetroCenter, 101 8th St., Suite 152, Oakland, CA 94607, (415) 540-2713); or the Southern California Earthquake Preparedness Project (1110 East Green St., Suite 300, Pasadena, CA 91106, (818) 795-9055).

TABLE 1

COMPARISON CHART OF SEISMIC HAZARD ORDINANCES				
Comparison Issue	Santa Rosa	City of Los Angeles	Santa Ana	Long Beach
Date program became effective	October 1971	January 1980	February 1980	January 1977
Code basis for lateral forces	1955 UBC	Hybrid - Approximately 1964 UBC	Same as Los Angeles	1970 UBC (originally 1976)
Time frame of retrofit	One year from date of notification (approximately one building per week; continuous noticing process). Completion approximately 1990.	Obtain permit within one year, complete within 3 years of notification. Time extensions of up to 7 years for full compliance.	Same as Los Angeles, except time extension 5 years maximum.	Three phases: One year from 1978 for excessive hazard. Five years from 1991 for intermediate hazard.
Total number of buildings	750 in first two risk categories	7,800	200	800
Building criteria: type, size or age	Assembly and office, retail, or restaurant buildings over 100 occupants initially, apartments and low occupancy buildings prior to 1958 except one-and two-family.	All unreinforced masonry building constructed prior to 1934 except single family or apartments with less than five units. Parapets under previous ordinance.	All masonry with less than 50% of steel reinforcing req. by 1979 UBC except single family or apts. with less than 5 units. Parapets included.	All occupancies, largely unreinforced masonry with four or more stories except single family. Parapets included.
Risk categories	7	4	4	3
Risk/hazard assessment criteria or schedule	Priority established by occupancy class and occupant load.	Based on occupancy class and primarily occupant load (UBC Table 33-A).	Same as Los Angeles	Based on occupancy class and load, severity of structural deficiencies; phased by occupant class and height.
Structural deficiency criteria	1955 UBC	Building lateral force resistance based on LA building code.	Same as Los Angeles	Ratio of lateral force capacity of the building to the required capacity based on 1970 UBC levels.
Appeal process	None	Board of Building Safety Commissioners for time extensions.	Uniform Code Appeals Board	Staff for up to 120-day extension; Board of Examiner, Condemnation for demolition order.
Potential for order to vacate or demolish	Yes	Yes		Yes
Built-in time extension	None	Yes, except for anchorage of walls.	Same as Los Angeles	None

asked the consultant to develop a matrix that listed type of construction, number of occupants, building components, and priority or urgency of repairs.

The initial division by occupants was a three-tier ranking:

- High-risk buildings — those with more than 100 occupants
- Medium-risk buildings — those with 20-100 occupants
- Low-risk buildings — those with fewer than 20 occupants

The committee decided that unreinforced masonry (URM) buildings would have top priority for seismic retrofit, and older concrete and steel frame buildings would have the next level of priority. Unbraced interior and exterior appendages would either be attended to along with collapse hazards or dealt with separately in a building that was otherwise sound.

A Simplified Classification System

The consultant, with the assistance of the structural engineers on the committee, developed several increasingly complex matrices. The proposed matrices included type of structural system, building age, number of stories, and building shape or configuration. Their complexity seemed likely to overwhelm the uninitiated, and would have been quite difficult to enforce in an ordinance.

In an effort to simplify the criteria, the structural engineer subcommittee proposed a division into two basic groups: (1) URM buildings, and (2) all others. The "all others" classification would be divided into categories according to number of occupants and date of construction. A breakdown of buildings into eight categories was developed, together with the estimated numbers of buildings in each group and a proposed schedule for initiating the program and completing necessary repairs. (Tables 2 and 3)

TABLE 2

BUILDING CATEGORY SYSTEM	
Category I:	All nonresidential unreinforced masonry buildings (estimated 50 buildings in category)
Category II:	All pre-1935 buildings with 100 occupants or more (25)
Category III:	All buildings with 300 or more occupants constructed between 1935 and 1976 (75)
Category IV:	All buildings with 100 to 300 occupants, constructed between 1935 and 1955 (100)
Category V:	All buildings with 100 to 300 occupants, constructed between 1955 and 1976 (150?)
Category VI:	All pre-1935 buildings (except residential buildings with 5 dwelling units or less) with 11 to 99 occupants (75)
Category VII:	All buildings (except residential buildings with 5 dwelling units or less) constructed between 1935 to 1955 with 11 to 99 occupants (200?)
Category VIII:	All buildings (except residential buildings with 5 dwelling units or less) constructed between 1955 to 1976 with 11 to 99 occupants, except wood-frame buildings of 3 stories or less without concrete parking garages below the lowest wood frame story (400?)

The committee based its building classification system on the following considerations:

- It would be difficult to determine the exact nature of a building's structural system, especially in older buildings, for which drawings are often not available.
- Height, number of stories, and total area could be eliminated because of their direct relation to a building's occupant load.
- There were essentially no seismic design requirements before 1935.
- Even after 1935, seismic code provisions were often inadequate, as demonstrated by earthquake damage observed during the past half-century.
- A simpler classification system would facilitate owner understanding of the probable impact on individual buildings and would also make it easier for the city to administer the ordinance.
- A building's presumed occupant load could readily be estimated from data on the building's area, using a table in the Uniform Building Code.

TABLE 3

PROPOSED SCHEDULES FOR SEISMIC HAZARD REDUCTION

Category	Number of Buildings	Engineering Analysis to be Submitted Within	File for Building Permit Within	Construction Commenced Within	Construction Completed Within
I	50	12 months	24 months	30 months	2-1/2 years
II	25	18 months	30 months	3 years	4 years
III	75	3 years	4 years	4-1/2 years	5-1/2 years
IV	100	4 years	5 years	6 years	7 years
V	150	5-1/2 years	7 years	8 years	9 years
VI	75	6-1/2 years	7-1/2 years	8-1/2 years	9-1/2 years
VII	200	8 years	10 years	11 years	12 years
VIII	400+	12 years	13 years	14 years	15 years

Notes:

A 12-month period between submission of engineering analysis and application for a building permit was selected to allow the engineer ample time to make decisions on the most economical repair method and to give the Building Division time to establish a priorities list, if appropriate, for each category. The 18-month period in Category V is based on the larger number of buildings involved, so that construction could be spread out over a greater time span.

Permit review and issuance time in Category I & II should be more than ample to allow construction commencement within 6 months. One year was chosen in Categories III & IV to allow for proper construction scheduling to avoid major disruptions of tenants; 18 months was chosen for Category V due to both the workload the Building Division would encounter and, again, to spread out the amount of simultaneous construction work, which could seriously disrupt the community.

Categories I through VI represent nearly 500 buildings repaired in 9-1/2 years.

External and Interior Hazards

In addition to rating building collapse hazards, the committee also attempted to classify external falling hazards into three risk categories (Table 4). They also considered a variety of hazard reduction implementation plans relating to external hazards. (See Exhibit 3). While building collapse is usually regarded as the most dangerous earthquake hazard in terms of the number of individuals exposed even in moderate earthquakes, casualties have also been caused by building appendages shaking loose. The committee considered marquees, parapets, masonry veneer, chimneys, roofing tile and other appendages as potential threats to pedestrians, occupants of adjacent structures, and persons who run outside during an earthquake.

The committee also considered interior building components such as suspended ceilings, lighting fixtures, piping, and a variety of other overhead equipment, all of which may fall during an earthquake even if the affected structure or its exterior appendages survive. Virtually all buildings have internal hazards whose reduction or elimination is usually less costly and disruptive than dealing with other seismic hazards.

The committee concluded that correction of internal hazards should be dealt with separately from other structural hazards with this action triggered when interior remodeling work requiring a building permit is conducted. The committee recommended that repairs to correct all internal hazards be required at the time of remodeling exceeding a value of $50,000 in buildings with less than 10,000 square feet. For buildings exceeding 10,000 square feet, however, only those internal hazards in remodeled areas and adjacent exit corridors would need to be corrected.

TABLE 4

EXTERNAL HAZARDS	RISK CLASSES
• Nonstructural exterior wall panels • Parapets • Marquees and awnings • Masonry wall veneer or wall ornamentation (including cornices and other decorative appendages) • Masonry chimneys • Tile roofing • Wall signs and exterior lighting fixtures • Fire escapes • Roof-mounted equipment	Class A Occurring on a building face or roof, adjacent to pedestrian access (entrances, courtyards and walkways, etc.) Class B Occurring on a building face or roof adjacent to a building whose roof is lower than the listed external hazard. Class C Occurring on a building face or roof which is not adjacent to the conditions described in A or B above

Recognizing Negative Impacts

The committee recognized that hazard mitigation would necessarily have negative impacts. (See Table 5 for a listing of negative financial impacts considered.) These include the direct cost of actual construction to repair a building, as well as the potential for serious business disruption during rehabilitation. Business tenants would be affected if they relocated while a building was being strengthened, and owners would also suffer a loss of rents. Inability to secure financing to perform repairs, or even to

do the initial structural investigation, coupled with the limitations on the potential for recovering those costs, could prompt an owner to sell a property or demolish a building.

TABLE 5

NEGATIVE IMPACTS - FINANCIAL
• Property owners affected by the ordinance may be facing extreme financial hardship in order to pay for required repairs, especially where they are tenants in their own buildings.
• Lack of a method of reasonable financing may force many building owners to demolish or sell rather than rehabilitate their buildings.
• Owners may have difficulty recovering the costs of rehabilitation due to practical economic or legal limits on rent increases.
• Tenants will incur costs of relocation and loss of income during the period of construction if vacating the building for repairs is necessary, and may not be able to financially survive.
• Tenants returning to repaired buildings may have higher rental costs.
• Owners will lose income from leases if the building is vacated for repairs.
• Tenant investment in interior improvements to a building may be lost or abandoned if the building requires repair or is demolished.
• Cost of design and construction services may be inflated if too many buildings are required to undertake repairs in too short a time span.
• Current availability of public funding mechanisms and the quantity of their potential assistance are very limited.
• The costs for engineering investigation, testing, and preparation of a report on the structural condition of a building will range from 75 cents to $1.50 per square foot. Small buildings should expect to have costs in the upper portion of this range with medium size buildings on the lower end. Large buildings (over 40,000 square feet) would be expected to cost from 25 cents to 50 cents per square foot. These costs will be borne by the building owner and may create or pose substantial hardship.
• The disclosure of information contained in the required report may affect the value of the building when negotiating its sale or refinancing.
• Owners of buildings found to be deficient or hazardous in the event of an earthquake may have difficulty maintaining or renewing insurance coverages.

Owners with serious external hazards, such as deficient architectural appendages, might permanently remove them rather than reanchoring them securely. Such outright removal could have adverse architectural impacts, especially on older buildings. (Readers should note that many older buildings come under the protection of the State Historical Building Code. Repair or remodeling done on such "historic properties" can be required to comply with regulations

designed to preserve the structures' architectural and historic character.)

Finally, an owner's liability for occupants' potential injury or loss of life may actually increase if reasonably prompt corrective action is not taken after an engineering report has revealed life-threatening deficiencies. Information on seismic deficiencies could affect the value of a property, causing difficulties in obtaining business and property insurance.

In the ordinance's final form as submitted to the city council, the committee recommended consideration of several mitigation measures to deal with potential negative impacts (Table 6).

TABLE 6

MITIGATION MEASURES RECOMMENDED BY CITIZENS' COMMITTEE
• The City should provide a program of low interest loans to owners required to submit an Engineering Report where the costs of such a report would create a hardship.
• The City should adopt a program allowing the sale of "air rights" or promoting the "density transfer concept" *prior* to enactment of this ordinance in order to mitigate the loss of historic buildings currently existing on underdeveloped sites.
• The City should develop and promote an educational campaign directed towards homeowners and business owners on the proper measures to take during a major earthquake and the type of preparations individuals should make prior to such an event.
• The City should develop an emergency plan focused on an earthquake disaster and hold regular City-wide drills on this plan.

The Committee's Mandatory Program

The Coalinga earthquake of May 1983 occurred during the ninth month of the committee's deliberations, and was felt by some committee members on their way to attend a committee meeting. At the very next session, Herman and Russell presented pictures of Coalinga damage. This motivated the committee to conclude its work and endorse an extensive mandatory repair program. The draft ordinance provided for investigation of more than 1,000 buildings over a fifteen-year period, and mandatory repair of any found deficient with respect to the 1973 UBC. (See Table 3). In approving such a massive effort, most committee members also agreed that the city should assist affected owners in dealing with the cost and disruptive effects of a mandatory program. After identifying these issues, the committee compiled the list of negative impacts and suggested the mitigation measures noted above.

The citizens' committee also met with local opposition when presenting the ordinance at a public hearing in September 1983. Even with provisions intended to ameliorate the impact on owners and occupants, such as low-cost rehabilitation loans to owners and relocation assistance to tenants, the response at the hearing was fully as negative as it had been at the 1982 hearing on the original staff-produced draft. The major concern voiced was with the mandatory repair requirement. Property owners tended once more to see the mandatory approach as impractical, partly because of its definite timetable and inflexibility. They maintained that if given some leeway they could find more appropriate occasions when upgrading would be easier to accomplish, e.g., when leases expire, building uses change, or ownership is transferred. In this view a mandatory approach would force remedial action to be taken

"prematurely" without regard for an individual owner's future business plans. Another concern regarded the lack of information on anticipated costs that owners might have to finance. There was fear that seismic repairs might prove economically infeasible for some owners, particularly if costs greatly exceeded demonstrable economic benefits. Answers were not then available for two main questions from owners: "How large is the seismic hazard in Palo Alto?" and "How much will this program cost the community?"

Finding a Compromise Solution

Following the September 1982 hearing, committee members who represented the interests of building owners made it clear they would not continue to support any program that included mandatory repairs. This led to a debate on mechanisms to trigger compliance, including a link between mandatory repair and substantial remodeling, lease expiration, or property sale and refinancing.

The proposal that sparked the most interest, however, was a voluntary approach requiring only that each building be analyzed and the resulting report made publicly available. The proposal had no timetable for required repair of buildings identified as hazardous. Instead, owners would decide what to do and when, influenced by the publicly available information on their buildings. (See Exhibit 4)

Proponents of the voluntary formula argued that receipt of an adverse engineering report would in itself tend to force an owner to strengthen a deficient building. It was anticipated that market forces, legal liability concerns, loss of insurability, possible shifts to alternative uses, and resale considerations would play major roles in owners' decisions. As noted earlier, during the hearing process owners indicated that they would make necessary improvements under such a flexible ordinance. Several owners stated, in effect, "If there are serious hazards in my building, and I am aware of them, I will have a responsibility to correct them."

This approach clearly departed from that taken by other cities, and differed from the usual way government obtains compliance with building safety policies. In fact, the city building official's initial dismay with the voluntary proposal prompted him to state that mandatory repair of URM buildings was the minimum he would accept. Without a mandatory provision, he would rather have no ordinance at all. At that time, he preferred to have nothing to do with a program that only identified hazardous buildings but provided no municipal authority to require repairs. The resulting conflict was intensified when the committee recommended that the building official be prevented from informing the council of the content of the building reports or of the status of owners' voluntary actions.

The final committee report embodied the concept of voluntary action, to be triggered, it was hoped, by disclosure of structural deficiencies. The citizens' committee unanimously approved the report and submitted it to the council's Policy and Procedures Committee in February 1984 (see Exhibit 5). An accompanying city staff report to the council committee countered the citizens' committee recommendations with others considered necessary to make the voluntary approach workable. The staff proposed that tenants be notified of the existence of reports on buildings, and that the owner of a building identified as having a collapse-hazard potential be required to submit a letter of intent indicating a schedule for remedial action. The staff report also recommended that the building official be required to report to the council on the status of voluntary actions every six months.

Conflicts between committee and staff recommendations were resolved at two meetings of the council Policy and Procedures Committee in February and May 1984. The result was a plan endorsing the voluntary concept, requiring building investigations and reports to be done over a five-year period, and covering approximately 350 buildings constructed before August 1976, a date only eight years prior to the presentation of the proposal. Owners of buildings with collapse-hazard deficiencies would be required to submit letters of intent stating their plans for correcting deficien-

cies. Finally, the building official would make semiannual status reports to the city council. On June 4, 1984, the city council unanimously approved the plan and directed staff to draft an ordinance based on those concepts.

Drafting and Passing the Ordinance

The technical portions of the earlier draft ordinances considered by the citizens' committee were written to implement mandatory repair. Accordingly a complete restructuring was required to accommodate the more limited investigation and reporting procedures of the voluntary approach. The enforcement procedures also presented a challenge, again due to the lack of a repair requirement. In reworking the draft, the consultant produced eight successive drafts of the administrative and legal portions, responding to commentary by the citizens' committee and revisions of language and detail by the city attorney and planning director.

A procedure for structural analysis had to be developed for the diversity of building types included. After much discussion with structural engineers, seismic resistance factors and structural considerations not fully covered in the Uniform Building Code were included, because recent earthquake experience had shown that those factors contributed significantly to collapse-hazard potential.

The special case of URM buildings also posed a problem, because the newly published Agbabian-Barnes-Kariotis (ABK) report differed from the then-current standards used in the cities of Los Angeles and Santa Ana. In November 1984, the citizens' committee authorized adaptation of the ABK work for use in Palo Alto's formula for investigation and reporting on URM buildings. This effort was pursued, but work on standards for evaluating other structural types was postponed until publication of the Proceedings of the Eighth World Conference on Earthquake Engineering (held in San Francisco in July 1984), in order to include as much up-to-date information as possible. There were difficulties in adapting the ABK report, however, and a valuable new document appeared in early 1985 that prompted abandonment of the ABK approach. Attention was turned instead to the Uniform Code for Building Conservation (UCBC), published by the International Conference of Building Officials (ICBO), the same organization that writes and publishes the widely used Uniform Building Code. The new UCBC included an appendix chapter on analysis and repair of URM bearing-wall type buildings, based primarily on the 1981 Los Angeles city hazardous building ordinance, organized in a codified format. With some further modification to remove the references to repair, this code was used for the Appendix B section of the Palo Alto ordinance. The ordinance's Appendix A was developed during the second half of 1985, using information from the Eighth World Conference covering the analysis of buildings other than of URM bearing-wall construction. The Appendix A draft was then circulated to various interested northern California structural engineers for comment.

The draft ordinance was put in final form and brought before the city council on January 20, 1986. After hearing comments from the public, including owners still opposed to these less stringent requirements, and structural engineers who supported the concept, the council discussed modifications in both content and scope.

A major point of contention was the proposed use of the 1985 UBC as a standard for evaluating structural adequacy. The staff considered it prudent to use the most up-to-date technical provisions, which were intended as a measure of structural deficiency rather than as reconstruction standards. Clearly, however, the 1985 code requirements went beyond the level of strength needed to avoid building collapse and to protect occupants from life loss and injury.

Accordingly, the council decided that a lesser code would suffice, due partly to concern that *all* buildings coming under the ordinance would be found inadequate by 1985 UBC criteria. The code agreed upon was the 1973 edition of

the UBC. The 1973 code had lower seismic force levels but, as one structural engineer stated to the council, the code nevertheless "should be an adequate measure of collapse resistance."

The other principal change reduced the scope of the buildings covered from six categories to three, removing more than 200 buildings from the program. This move became almost inevitable after the council had considered and rejected other ways to reduce the impact of the ordinance. The council had also decided against providing any financial assistance to owners. Thus reducing the number of buildings covered was the only remaining option for attempting to accommodate those who still opposed any action on existing buildings.

One other last-minute change, primarily motivated by a desire to spare the only remaining small grocery store in the downtown, eliminated URM buildings with fewer than seven occupants and less than 1900 square feet. Finally, as a concession for historic buildings, the sending of notices to their owners was delayed 18 months, allowing time for further study of alternatives for those buildings.

Conclusion: Ordinance Implementation and Results So Far

The ordinance was adopted in January 1986, and on May 11, 1986, official notifications were mailed to owners of 68 buildings. The remaining 24 historic structures received their notices in November 1987.

Early Data on Compliance

At this writing, more than four years after the first notices were sent, the ordinance has brought about a significant reduction in seismic hazards. Thus far, over 1,570,000 square feet of the floor area included in the program's three building categories has been seismically rehabilitated or demolished. The following tabulation of owner actions is based on information reported by October 1990:

Total number of buildings	92
Buildings strengthened	27
Buildings demolished	5
Engineering reports accepted	46
Projects in progress	3
Engineering reports not accepted or overdue	13

The city has contracted with an engineer to review the reports submitted, and to check on their conformance with the requirements in Appendix A and B. As of October 1990, the city had rejected 4 of the 50 reports submitted.

While it is clear that for a variety of reasons some owners are delinquent in submitting the required reports, the early results—with 35 percent of the affected buildings already strengthened or demolished—do help dispel some of the skepticism about owners responding by removing or repairing hazardous buildings. The real, long-term test of the ordinance will, of course, depend on the findings of the engineering reports on the other buildings and on the actions taken by the owners.

The Floor Area Incentive

The program's early success can be attributed in part to the incentive of the seismic upgrade exception under Palo Alto's strict zoning ordinance, which in return for seismic strengthening confers eligibility to increase square footage in the downtown area without providing additional parking. Indeed, this incentive was so attractive that several owners of buildings not covered in the program's inventory actually requested that their properties be included. If they could have come into the program, they would have been willing to perform seismic upgrading in exchange for the opportunity to expand floor area.

In the spirit of promoting seismic safety, the city planning department has extended the incentive to allow owners of nonhistoric buildings to benefit, if they demolish a building included in the program and replace it with a new structure. This action by the planning department enables the added floor area to be applied to new buildings that replace demolished buildings. It is assumed that economics is the controlling factor in determining whether removal and replacement is more practical than rehabilitation.

Despite its appeal to some owners, there are also limitations to the floor-expansion incentive. It applies only to smaller URM buildings on downtown lots that are underbuilt with respect to the maximum allowed floor area under zoning provisions (3:1). Beyond an early flurry of interest, the incentive has not been widely used, although by now most who might be interested can be presumed to have acted, or decided against it.

Direct and Indirect Results

While the actions taken so far under Palo Alto's voluntary ordinance are modest, they have exceeded the expectations of some of its drafters. The chief building official, for example, did not anticipate getting any significant action. But the ordinance has had a definite direct impact, and progress is being made. On the other hand, quite a few reports have been submitted indicating potential hazards, but the owners have not initiated action.

In addition to its direct effects, the indirect impacts of the ordinance must

be considered. They appear to be surprisingly strong. Buildings not covered by the program are also being seismically upgraded, principally due to the influence of the ordinance. In fact, nearly as many buildings not under the ordinance have been rehabilitated as those that are.

In part, this response is attributable to the way the ordinance is being administered, and to city building agency's proactive role in "talking up" the rationale behind the ordinance and promoting the merits of seismic rehabilitation. For example, when owners consider remodeling the city encourages them to do a seismic upgrade at the same time, even when it is not mandatory. Also, one owner of an existing nonductile concrete-frame building included in the program has received a variance from the city's very sacred height limit, granted solely because the owner was willing to rehabilitate the building seismically.

In a variety of ways the city has been sending signals that seismic rehabilitation is a good thing. The occurrence of an occasional damaging earthquake, such as the Whittier earthquake in 1987, helped keep the topic alive, as did passage in 1986 of Senate Bill 547, the state law requiring URM review. Undoubtedly the Loma Prieta earthquake of October 17, 1989 will have a substantial impact. As this is written it is too early to see what the local response may be, but the recent earthquake is likely to prompt additional owners to strengthen their buildings.

As of November 1990, 159 California cities and counties have established URM hazard mitigation programs. Seventy-nine require strengthening of the buildings, and twenty-nine cities have adopted ordinances similar to Palo Alto's. Forty others have only notified building owners and have not adopted standards. Dozens of other cities and counties are giving serious consideration to a Palo Alto-type ordinance.

A Palo Alto-type ordinance goes a good deal farther than simply notifying building owners. In addition, it offers a comprehensive management system including evaluation reports, letters of intent and periodic reporting to the city council.

Notification-only programs are fraught with problems. First, building owners are not encouraged to strengthen or otherwise reduce their earthquake hazards. Since no standards are adopted in such a program, owners cannot easily make economic decisions about the futures of their buildings. And, most importantly, owners who do not learn of the specific hazards of their building through an evaluation report are likely to react to a general notice that their building is "potentially hazardous" with disbelief and outrage.

Reconsidering the Ordinance

The city will probably reconsider the ordinance, reviewing the experience so far, as well as the implications of the Loma Prieta earthquake. The ordinance had its fourth anniversary in January 1990. Even without the recent earthquake it would have been about time for the city to take a second look at the measure, and especially the effectiveness of the voluntary feature.

Under voluntary rehabilitation, are some owners likely to be long-term holdouts? If so, should stronger incentives be provided, or more stringent measures such as mandatory rehabilitation? Should buildings in the three categories originally proposed but dropped from the ordinance be added? Basically the buildings in categories IV, V, and VI are similar to those in categories I, II, and III, but have smaller numbers of occupants. Should coverage also be extended to other types of buildings that may be hazardous?

Many cities have shown interest in the Palo Alto ordinance. It is attractive partly because proponents in other communities can say: "Here is something that has been tried locally." There is also concern, however, that some jurisdictions may see Palo Alto's voluntary formula as a relatively easy way out. It is less intrusive than a mandatory approach, imposes less of a burden on affected owners, and is not as controversial. But it also may not work as well in some other jurisdictions that are less affluent than Palo Alto, or where the economics of the affected buildings, or the affected owners, may militate against action.

In addition to economic factors *per se*, the mindsets of owners are also influential, including the way they *see* themselves economically, along with other factors that influence their point of view and philosophy. Owners who are entrepreneurs, or who have several buildings and are in the "business" of owning buildings, may ask: "Can I make money through rehabilitation and structural remodeling?" In contrast, the owner of a single building may ask: "Can I afford this, or will it break me?" "Will I even be able to get a loan to do the rehabilitation?"

If an ordinance like Palo Alto's is applied to additional and newer types of buildings, this will bring in many corporate owners and introduce other considerations. Corporate responses depend largely on the attitudes and policies of top management. Some local corporate owners—such as Hewlett-Packard—are doing a good job on their own, methodically upgrading their buildings and developing effective emergency response planning programs. On the other hand, some corporate managements have proven more reluctant to undertake seismic rehabilitation, or appear downright negative.

Finally, we have noted the role of the Palo Alto building department in actively promoting seismic rehabilitation. A city building department that is passive or indifferent to seismic retrofitting, rather than actively promoting it, will not have a positive influence on owners' responses to a voluntary ordinance. In short, cities considering a seismic rehabilitation program ought to consider all aspects of their situation, including their community's needs, goals, and resources. They should not adopt the Palo Alto ordinance—or any other ordinance—merely because it is available and has been used locally.

The concept of the Palo Alto voluntary approach came along at the right time, with the right audience, and with the right economic mix. That is why it was adopted in the first place. The ordinance and the way it has been administered has increased public awareness and perception of the hazard. Owners have made reports under the ordinance, and a certain number of them have repaired or demolished their buildings, or propose to do so. In addition the ordinance has encouraged rehabilitation of many buildings that were not formally covered. One can conclude that Palo Alto's experience is a case of "so far, so good." Palo Alto has made progress under its voluntary seismic rehabilitation ordinance, but still has a long way to go.

Exhibit 1

Potential Financing Arrangements and Programs that Could Assist Owners and Tenants

EXHIBIT I

Potential Financing Arrangements and Programs That Could Assist Owners and Tenants

- *AB 604 bond revenues loaned to owners of URM buildings who meet eligibility criteria.* These loans originate through an underwriter, who will allow the city to pass through to owners, via lower interest rates, the benefit of the city's tax–exempt status. Interest rates for cash outlays for these loans would be near the tax–exempt financing rate of 8.5%. The city would incur only small administrative costs and underwriter fees.
- *Commercial loans by banks to owners of any type of affected buildings who can qualify with bank lending criteria (adequate equity and ability to sustain a second or third deed of trust).* These privately applied-for loans, from a bank with whom the city chooses to do business, could be made at below-market rates of interest if the city deposits a compensating balance in that bank.
- *Commercial loans to owners otherwise unable to qualify with bank lending criteria where the city guarantees the loan by placing 100% or some negotiated amount of the loan value into an account with that lender.* This alternative is a considerable risk and a great cost to the city.
- *Small Business Administration loans to small businesses that own the building in which they operate.* These loans could be made by a bank based on the records of the businesses' financial condition by establishing deeds of trust against the properties. This is a federal program in which the city would not be a participant.
- *City bonds.* The city could choose to sell bonds similar to industrial development bonds, which would be used to form a pool of financing at tax-exempt bond interest rates under its own set of standards for eligibility. Other than administrative and underwriter costs, the city would not incur a cash outlay for this type of assistance.

Exhibit 2

Financial Assistance Alternatives for the New Seismic Ordinance

EXHIBIT 2

M E M O R A N D U M

August 10, 1983

TO: Palo Alto Seismic Hazard Committee

FROM: Gordon Ford G.B.F.

SUBJECT: Financial Assistance Alternatives for the New Seismic Ordinance

It is my understanding that the committee will present its recommendations to the City Council in October, 1983. In your report to the City Council there should be some discussion as to the need for financial assistance followed by a comment that the financial alternatives are suggestions of what the City could do to mitigate some of the impact on property owners if the ordinance is adopted.

Alternative I -- AB 604

AB 604 is an assembly bill which was approved by the Governor on September 30, 1982 and authorizes a city, county, or city and county to provide financing, as provided, for costs to owners of "eligible buildings," as defined, in making structural or other modifications in order to meet local reconstruction standards. The local agency may provide financing only if the legislative body of the local agency makes one of the following findings:

a. The owner to whom financing would be made available pursuant to this division is unable to qualify for or could not afford financing for eligible costs from private lending institutions.

b. Absent the availability of financing pursuant to this division, the eligible building would be demolished.

c. Absent the availability of financing pursuant to the division, the costs of modifying the eligible building to meet reconstruction standards, pursuant to Section 19162, 19163, and 19163.5, would cause severe economic hardship to the business in the building.

It is unlikely this bill will provide any assistanct to Palo Alto. Since Palo Alto is a Charter City it is possible to issue tax exempt financing without this bill. The bill requires that the owners of the property supply detailed financial information and prove hardship. The committee should consider sending a letter to the few property owners who might qualify for this financing to confirm there is no desire for use of AB604.

Alternative II -- Tax Exempt Financing

The City of Palo Alto could consider other forms of tax exempt financing in order to pass the lower interest rate to the property owners. At this time, this is currently possible using Charter City Industrial Development Bonds. Other forms of financing such as Assessment District Financing may be possible, but these details can be developed later. The City's financial advisor, Frederick Waldeck, of Security Pacific Capital Markets Group, has given some of the details and concerns in the attached letter dated July 22, 1983. While there are some difficulties, such as accessibility to the market place due to the credit requirements, they can be solved at a later date.

There are two important points which should be clearly identified in your report:

(1) The City could provide this assistance only it if is legally possible. As indicated above, it is legally possible at this time, however, laws could be changed and the City should not be committed to provide assistance if there are adverse changes in laws. This program is expected to operate for a number of years and there has been some concern expressed regarding the use of City Industrial Development Bonds. We also understand Mr. Jarvis is considering a new initiative which could affect cities.

(2) Some eligibility criteria will be needed. While the City of Palo Alto may be able to make loans which might not be approved by a bank, the City should protect itself from possible defaults. The bonds can probably be sold based on the building and not use the credit of the City of Palo Alto or be secured by the City of Palo Alto in order to qualify lower credit rates or lower the interest rates. This detail should also be left for a later date.

It would be helpful to refer to the Lytton Garden project to remind the Council of their past actions in this area.

In 1983, the City of Palo Alto issued $10,400,000 Revenue Bonds for Lytton Gardens Convelscent Hospital. The series 1982 Bonds were issued by the City of Palo Alto pursuant to the City of Palo Alto Health Facility Financing Law. The bonds were insured as to the payment of principal and interest by the Office of Statewide Health Planning and Development under the California Health Facility Construction Loan Insurance Law. The bonds did not constitute debt or liability of the Cilty or a pledge of its faith and credit and the issurance thereof did not obligate the City to levy or pledge any form of taxation or to make appropriations of their payment.

Alternative III -- Interest Buy Down

The City of Palo Alto could consider allowing the property owners to qualify for a loan and the City could then buy down the interest rate.

This could be accomplished in one of two ways. First the individual property owner would apply to a bank for a loan. After the loan is granted, the City would make arrangements with the bank to reduce the interest rates. Second the City would establish a program with a bank and the loan would be reduced when the individual property owner qualifies.

Exhibit 3

External Hazard Reduction Implementation Plan

EXTERNAL HAZARD IMPLEMENTATION PLAN

A. Incorporate External Hazards into a single ordinance dealing with building collapse hazards.

B. Exclude all single family and two family dwellings.

C. Basis for Rating Buildings:

1. Location - A population density study would be performed to establish zones of high, medium and low pedestrian density within the commercial/retail areas in Palo Alto. Buildings located in a high pedestrian density zone would be placed into the earliest time frame for engineering analysis with subsequent zones having separate and longer time periods.

2. Class of Hazard - Class A, B and C Hazards (See Table 4) would be identified on all buildings within each pedestrian density zone. Hazard point values equal to 5, 3 and 1 would be assigned respectively to each of the Class A, B or C Hazards found on each building. The total score for each building within a given pedestrian density zone would provide a basis for establishing the individual due date for the required analysis within each of the three time periods established by #1 above.

D. Separate external hazard rating criteria from those used to evaluate the hazard from building collapse and provide separate time schedules for their evaluation. At the owner's option both external hazards and collapse hazards could be evaluated at the same time using the earlier of the two deadlines.

Exhibit 4

Seismic Hazards Ordinance Outline

EXHIBIT 4

SEISMIC HAZARD ORDINANCE OUTLINE
OCTOBER 1983

I. PURPOSE

Downtown Palo Alto lies less than six miles from the foothills trace of the San Andreas Fault and may be expected to experience a strong local earthquake in the future. In the event of a strong local earthquake, unnecessary loss of life or serious injury may result from falling debris or collapse of buildings. This Committee believes that it is desirable to identify those buildings that are seismically hazardous, in order to accurately determine the severity, extent, and costs involved in correcting structural deficiencies. This ordinance would reveal information essential to the assessment of the risks and costs involved in any future requirement for structural repair of buildings in Palo Alto, and require correction of External and Internal Hazards.

II. SCOPE

Seismic Hazards have been divided into three major types:

A. Building Collapse or Partial Collapse - The hazard posed by the actual structure of a building collapsing onto its occupants, pedestrians, or the occupants of adjacent buildings. Of the three types of hazards, building collapse is regarded as the most dangerous in terms of the total number of individuals potentially exposed. Within the various categories of buildings, those constructed of unreinforced masonry are the most susceptible to life threatening failure, in even moderate earthquakes.

B. External - The hazard posed by objects attached to or forming the exterior of a building which may fall onto pedestrians or occupants of adjacent buildings. Falling marquees, parapets, masonry veneer, chimneys, roofing tile, and other appendages pose a serious threat to pedestrians, occupants of adjacent buildings, or those fleeing their own building.

C. Internal - The hazard posed by objects suspended at or above the ceiling level, inside buildings, which may fall onto occupants of the building. Suspended ceilings, lighting, piping, and other overhead equipment may fall even when the structure or exterior appendages of the building survive an earthquake.

This Committee believes that all three types of hazards should be examined and deficiencies corrected by the methods suggested in this document.

III. BUILDING COLLAPSE HAZARD CATEGORIES AND IMPLEMENTATION SCHEDULE

A. Building Categories - The following categories of buildings are defined in order of relative risk to the occupants, based on their susceptibility to collapse and the potential number of occupants at risk.

B. Owner Notification - The owners of buildings in Categories I, II and III will be notified immediately upon enactment of this ordinance by the Building Inspection Division. Owners of buildings in the remaining Categories will be notified within six months.

= C. Implementation Schedule - The times shown on the following chart are reckoned from the date of notice mailed to the building owner by the City.

BUILDING CATEGORY SYSTEM AND IMPLEMENTATION SCHEDULE

CATEGORY	DESCRIPTION	ESTIMATED NUMBER OF BUILDINGS	ENGINEERING REPORT SUBMITTED WITHIN
I	All Unreinforced Masonry Buildings (URM) except Residential buildings containing less than 6 dwelling units	50	18 Months
II	All Pre-1935 buildings other than URM with 100 occupants or greater	25	18 Months
III	All buildings with 300 occupants or greater constructed between 1935 -1976	75	2-1/2 Yrs.
IV	All buildings with 100 - 299 occupants constructed between 1935 - 1955	100	3-1/2 Yrs.
V	All buildings with 100 - 299 occupants constructed between 1956 - 1976	200	4 Yrs.
VI	All Pre-1935 buildings with 11 - 99 occupants except residential buildings with less than six dwelling units	75	5 Yrs.

IV. EXTERNAL HAZARD CLASSIFICATIONS AND TIME SCHEDULE FOR IMPLEMENTATION

A. Ranking System for Hazards - As defined in Section X, External Hazards have no particular order of potential risk, but rather it is assumed that any particular one of these hazards may fall in a strong earthquake if it is inadequately braced.

B. Building Risk Classification and Scope of the Program

1. All buildings except residential buildings containing less than six dwelling units should be made to comply with the standards established in Section VI, Paragraph B.

2. Individual buildings will be grouped into three categories based on their location in relation to the potential pedestrian density in the area surrounding the building. Areas of High, Medium, and Low Pedestrian Density will be mapped based on a thorough study of pedestrian population in all the non-single family areas of the City.

3. Each individual External Hazard found to exist on a building face or roof should be classified and assigned points according to its location on the building in relation to one of the following classes.

Class A Hazard - 5 Points	Occurs on a building face or roof area which is adjacent to a pedestrian access (entrances, exits, courtyards, walkways, alleys, etc.)
Class B Hazard - 3 Points	Occurs on a building face or roof area adjacent to another building whose roof is lower than the External Hazard in question.
Class C Hazard - 1 Point	Occurs on a building face or roof area which is not adjacent to either a pedestrian access nor another building, but where open space does adjoin this building face.

4. This system is weighted to provide improved public safety in locations of the greatest pedestrian exposure based on the dual criteria of building location and the number of and type of hazards present.

C. <u>Owner Notification and Points Ranking</u>

1. Buildings in each Zone should be surveyed by the City and an ordered ranking of the buildings within each Zone should be compiled based on the number of points each individual building accumulates. Buildings having the greatest number of points will be required to have documentation on the adequacy or inadequacy of the attachment of the hazards submitted for review first.

2. Building owners in each Zone should be notified of this information and be advised of the time in which they must submit the documentation in accordance with the following schedule.

D. <u>Implementation Schedule</u> - The times indicated in this Table are reckoned from the date of notice mailed to the owner by the City, but any building may have this time extended up to one year with the approval of the Appeals Board.

PEDESTRIAN DENSITY ZONE	NOTIFICATION[1] SENT WITHIN	DOCUMENTATION[2] SUBMITTED WITHIN	FILE FOR[2] PERMIT WITHIN	COMPLETE[2] REPAIR WITHIN
HIGH	6 Months	12-24 Months	18-30 Months	2½ -3½ Years
MEDIUM	18 Months	24-36 Months	2½-3½ Years	3½ -4½ Years
LOW	30 Months	3-4½ Years	4 -5½ Years	5 -6½ Years

1 The time period from date of ordinance adoption until all owners in that Zone receive notice.

2 A range of time is indicated within which a specific date for compliance will be required based on the point ranking of a given building.

V. INTERNAL HAZARDS

A. Scope - These potential Hazards as defined in Section X, are present in virtually every building and should be dealt with in a manner insuring widespread correction of any deficiencies. Tying this work to only those buildings which require rehabilitation for Collapse Hazard or External Hazard cases will not suffice.

B. Implementation - This committee suggests that these Hazards be addressed by amending the Building Code as adopted in Palo Alto, to require proper bracing of all these items, at any time a permit exceeding $50,000 is applied for to remodel or repair any building except residential containing less than six units.

1. In buildings exceeding 10,000 square feet, only the Internal Hazards in the remodeled or repaired area and in corridors adjacent to these areas need to comply. In buildings 10,000 square feet or smaller in total floor area, all Internal Hazards within the building must comply.

2. Buildings requiring structural repairs to meet the minimum standards for bracing and anchoring of External Hazards need not comply at the time a permit for those repairs is issued regardless of the permit valuation. However, any permit exceeding $50,000 for repairs or remodeling prior to or subsequent to that permit will trigger compliance.

C. Recommended Action - This Committee also urges the City to distribute information regarding the potential hazard posed by other internal building components such as shelving, file cabinets, and bookcases, contents of such shelving or bookcases, and window glass. No requirements for bracing any of these items shall be required, but it is hoped that voluntary measures might be taken by those responsible to secure these potential falling Hazards.

VI. STANDARDS FOR THE ENGINEERING INVESTIGATION AND REPORT

A. Building Collapse Hazards

1. Unreinforced Masonry Buildings (Category I) - An engineering report on these buildings should be based on the analysis procedures for Unreinforced Masonry Buildings, contained in Chapter IX, Division 88, Sections 91.8808, 91.8809, and 91.8810 of the Los Angeles Municipal Code. This would include In-Place shear tests or core tests to determine the strength of mortar joints, removal of some existing floor or ceiling finish materials to determine the anchorage of roof and floors to walls, but should not require any disruption of the tenants in a building.

2. Category II through VI Buildings - An engineering report on these buildings should be based on an On-Site inspection of the building and a thorough review of all available construction and design documents. The location, size and capacity of existing shear walls or frames must be investigated by appropriate testing or review of original drawings and calculations. Their lateral force capacity should be determined by calculation using current established values for wood and plaster or steel, and by test values for concrete or concrete masonry. All connections of diaphragms to shear walls or frames, connections of walls to foundations, connections of precast panels to columns and other connections restraining movement due to lateral forces must be investigated by either uncovering the connection if drawings are not available, or by using existing construction drawings.

3. Content of Report
   a. A description of the building including: 1) the street address; 2) the type of occupancy with separate uses (lease areas) indicated on a plan indicating the square footage of each area; 3) a plan showing the location and type of lateral force resisting system in the building; and 4) a description of the construction materials used in the building.
   b. A narrative report on the method of investigation, review, and analysis of structural elements including shear walls, frames, disphragms, bracing, chords and ties to determine or estimate their capacity individually and as a system to resist lateral forces. This narrative must be supported by calculations, drawings or other data to substantiate the findings made.
   c. A description of the repairs or corrective measures which would be necessary to make the building meet the lateral force requirements of the 1973 UBC (for Category II-VI) or the Los Angeles Municipal Code (for Category I). This should not be construed to mean a requirement for a complete set of working drawings, but rather a description setting forth the location, extent and quantity of work (supported by sketches) needed to correct determined and suspected deficiencies. This portion of the report should be sufficiently detailed to allow a preliminary cost estimate to be derived.
   d. A summary of findings regarding the building's deficiencies, if any, in regard to its ability to resist lateral forces and its potential hazard to occupants in an earthquake.

VII. STANDARDS FOR REHABILITATION AND ANALYSIS

A. External Hazards

1. Standards - The Committee recommends using the requirements and analysis procedure contained in the 1982 Uniform Building Code Section 2312(g) as a basis for determining the adequacy of anchorage or bracing, and the ultimate repair of those hazards found to be deficient, in all except Unreinforced Masonry Buildings. The requirements for these buildings are found in Section 91.8808 of the Los Angeles Code referenced above.

2. Comparison of Lateral Force Levels - The 1982 Uniform Building Code uses lateral force levels that are 80% of those required in the 1964 Code for parapets and building appendages.

B. Internal Hazards

1. Standards - The Committee recommends the use of the requirements for bracing interior hazards based on the 1982 Uniform Building Code Table 23-J with reference made to the suggested methods of bracing given in the 1982 "Guidelines for Seismic Restraint of Mechanical and Plumbing Systems" published by the Sheet Metal Industry Fund and the Plumbing and Piping Industry Council.

VIII. RESPONSIBILITIES OF THE BUILDING OWNER

A. Building Collapse Hazard Reduction

1. The owner(s) should employ a Civil or Structural Engineer, as defined in Section X, to prepare the engineering report of the building pursuant to the standards set forth in Section VI, Paragraph A.

B. External Hazard Reduction

1. The owner(s) shall provide the Building Inspection Division with documentation (engineering data, testing, product standards, etc.) to ascertain the lateral force capacity of the attachment or bracing of all the External Hazards on the building.

2. Where any of these External Hazards are found to be inadequately attached or braced, the owner shall prepare a design for strengthening them and shall submit this design or method for a building permit.

3. Upon approval of the design or method and the issuance of a building permit the owner shall commence and complete all the necessary repairs.

4. All of these actions are required to be completed in accordance with the time schedule set forth in Section IV, Paragraph D, unless additional time is granted by the Appeals Board.

C. Internal Hazard Reduction

1. The owner(s) should submit details for the anchorage of internal hazards along with the plans for any remodeling or repair to the building which exceeds $50,000 in valuation, when required by Section V, Paragraph B.

2. Upon issuance of the permit for remodeling or repair the owner shall commence and complete all the necessary repairs.

IX. RESPONSIBILITIES OF THE CITY

A. Building Collapse Hazard Reduction

1. The City should prepare an accurate list of buildings in each category and notify the owner(s) of these buildings within the times specified in Section III, Paragraph B. The notification should specify the Category in which the building is classified, the cause for that classification and the time schedule for its compliance. A complete copy of the ordinance should be included with this noticing.

2. The City should provide a listing of engineers with experience in structural rehabilitation compiled by the local chapters of the Structural Engineers Association and the American Society of Civil Engineers.

B. External Hazard Reduction

1. The City should perform a Pedestrian Population Density Survey of all non-single family areas of the City and produce a map showing the limits of zones of High, Medium, and Low Density.

2. The City should inspect each building and compile a listing of potential External Hazards on each building. Based on the quantity and classification of those Hazards on the building, a total point score will be established in accordance with Section IV, Paragraph B.

3. The City should prioritize the buildings in each zone, using the point scores to establish the order in which buildings are to be investigated for deficiencies.

4. The City should then notify the building owners of the Zone their building is in and the date by which they must submit documentation of the adequacy of attachment or bracing of those Hazards. This notification must be made within the time specified in Section IV, Paragraph D, and should include a copy of the entire ordinance along with a list of the specific Hazards located on the building.

C. Internal Hazard Reduction

1. The City should notify the owner and applicant for a permit to remodel or repair any building except residential with less than six units, that the building will be required to comply with an amendment to the Building Code regarding bracing of Internal Hazards in accordance with Section V, Paragraph B.

2. The City should notice organizations representing Architects, Engineers, and Contractors of this change to the Building Code.

D. Information and Assistance

1. The City should provide owner(s), or their architect, contractor, or engineer with assistance in obtaining the most current information on proper methods of complying with this ordinance and should schedule workshop type meetings to educate these groups about the ordinance.

2. The Building Inspection Division should place a high priority on the processing of any permit application addressing the Hazards included in this ordinance.

X. DEFINITIONS

A. "Civil or Structural Engineer" means a licensed Civil or Structural Engineer registered by the State of California pursuant to the Rules and Regulations of Title 16, Chapter 5 of the California Administrative Codes.

B. "External Hazard" means a portion of a building which may fall onto pedestrians or occupants of adjacent buildings. Examples of this type of Hazard including the following:

1. Non-structural exterior wall panels such as masonry infill or decorative precast concrete.
2. Parapets
3. Marquees, awnings or other roof like projections from a building
4. Masonry or stone wall veneer and wall ornamentation including cornices or other decorative appendages
5. Masonry chimneys
6. Tile roofing
7. Wall signs and exterior lighting fixtures
8. Fire escapes or balcones
9. Roof mounted equipment

C. "Internal Hazard" means a portion of a buildings' contents which may fall onto the occupants of that building. Examples of this type of Hazard include:

1. Suspended light fixtures
2. Suspended ceilings
3. Suspended ductwork and mechanical equipment
4. Suspended piping
5. Suspended electrical equipment

D. "Occupants" mean the total occupant load of a building determined by Table 33-A of the 1982 Uniform Building Code or the actual number of occupants in that building if that number is less than 75% of the number determined by Table 33-A. The procedure for documenting the actual occupant load in a building will be established by the Building Official.

E. "Pedestrian Density Zone" means a specific area within the City of Palo Alto where pedestrian populations have been determined by a survey counting the number of individuals passing along the sidewalk at three separate times of day in any given block of that area.

F. "Pedestrian Way" means any area used or constructed in a fashion that it may be used by pedestrians. Examples of these areas include:

1. Public sidewalks, alleys, and plazas
2. Private sidewalks, walkways, paths or other regions leading to or from building entrances or exits or passing along a side of the building.

G. Unreinforced Masonry Building ("URM") means any building containing walls constructed wholly or partially with any of the following materials:

1. Unreinforced Brick Masonry
2. Unreinforced Concrete Masonry
3. Hollow Clay Tile
4. Adobe or Unburned Clay Masonry

Exhibit 5

Final Report from the Palo Alto Seismic Hazards Committee

February 2, 1984

FINAL REPORT FROM THE PALO ALTO SEISMIC HAZARD COMMITTEE

Members of the Council:

BACKGROUND

This Committee was formed by City Council action on May 24, 1982, when the staff was directed to form a committee of citizens to draft an ordinance which would have two effects: 1) an effective exterior hazard program and; 2) that this committee return to the Policy and Procedures Committee with some practical, cost effective and economic approaches to alleviate seismic hazards in Palo Alto. The Committee has met bi-weekly since September 21, 1982, to consider the wide variety of issues involved in recommending a suitable program to address seismic hazards in Palo Alto.

COMMITTEE MEMBERSHIP

Name	Organization Represented
John Northway (Chairman)	Planning Commission
Richard Pennington (Vice Chairman)	Downtown Merchants
Scott Carey	Board of Realtors
Virgil Carter	Architectural Review Board and American Institute of Architects
David Jury	Chamber of Commerce
Ann Miller	Downtown Merchants
Don Mullen	Downtown Palo Alto Inc.
Robert Nerrie	Historic Resources Board
Clarence Rinne	Structural Engineers Assoc.
Roland Sharpe	Structural Engineers Assoc.
Ted Thompson	California Avenue Area Development Association
Gordon Wright	Chamber of Commerce

INTRODUCTION

This report contains three sections, 1) a narrative explanation of the methods used in developing the ordinance and the purposes and philosophy on which it is based; 2) a commentary on the negative impacts which this ordinance may produce, and; 3) an explanation of the mitigation measures the City should implement to moderate the severity of the impacts and to promote public awareness regarding earthquakes.

METHODS, PURPOSES and PHILOSOPHY

The issues surrounding a policy of Seismic Hazard Reduction are diverse and quite complex. The Committee systematically reviewed all the topics listed in the "Issues Discussed" attachment prior to making their recommendations.

The requirements of the Seismic Hazard Identification Program were developed to provide a practical approach to balancing public safety concerns with the variety of negative impacts such a program could produce. The Committee considered many approaches, all with some drawbacks, and weighed the benefits and disadvantages of each. One major obstacle was the lack of definite information on the extent and severity of structural deficiencies present in the buildings under consideration, and a grasp of the total costs that repair of those deficiencies would entail. It became clear that without this information, Committee support and community support for an ordinance requiring repair work, would be impossible.

As a result the Committee developed an approach of investigation into these issues by requiring an engineering report on both the question of building collapse hazards and external hazards. These reports will contain an analysis of the potential hazards present and specific recommendations on the repair work necessary to correct all deficiencies discovered, in a format which can be used to produce cost estimates.

The purpose of this approach is twofold, it will; 1) reveal the extent of seismic hazards present in Palo Alto and enable owners to gauge the costs and disruption that repairs would involve, and; 2) provide an incentive to building owners, where potentially hazardous conditions are revealed, to correct them in a timely fashion. This incentive is based on the view that increased liability and potential effects on a building's value, as a result of the legal requirement of disclosure of any deficiencies, will encourage voluntary strengthening of buildings throughout Palo Alto.

Building Collapse Hazards

The scope of this program is more extensive than the ordinance reviewed by the Council in May 1982, and includes buildings of more recent construction than any existing seismic ordinance now in effect anywhere in California. The reasoning for inclusion of these buildings is based on both the quantity of people occupying them (over 100 occupants), and the substantial changes in the requirements for earthquake resistant design of structures, since their construction.

The total number of buildings to be reported on over a 5½ year span is estimated by staff to be 500 for Categories I through VI. The priority system and time schedule for submitting the engineering reports are based on an assessment of the relative risk each category poses in terms of original design standards and the number of occupants at risk. This system provides for an orderly progression, with sufficient time for both the owners to prepare the reports, and for the Building Division to manage the flow of information and provide technical assistance.

Buildings constructed in Palo Alto prior to August 1976, were required to be designed according to the 1973 (or earlier editions) of the Uniform Building Code. This code has the identical earthquake force levels specified by earlier codes but contains newer connection requirements, shown to be essential in preventing collapse or partial collapse of buildings, during the 1971 San Fernando earthquake. Upon adoption of the 1976 Uniform Building Code, the magnitude of forces used to simulate earthquake loads were increased by 40%, to more closely approach the level of forces known to be generated in actual earthquakes. As a matter of practicality and to provide a reasonable but not current level of safety, the reference standard for ascertaining deficiencies will be based on the 1973 UBC.

Buildings constructed prior to 1935 were not required by state or local laws to have any specific design requirements for earthquake forces and unreinforced masonry buildings have been definitely shown to be potential hazards in recent California and Idaho earthquakes. The Committee's recommendation, as a result, was to include all unreinforced masonry and other pre-1935 buildings with an occupant load exceeding 10, and all high occupancy buildings (100 occupants or greater) built prior to the standards set forth in the 1973 UBC.

External Hazards

Buildings requiring a report on external hazards will include most, if not all those in Categories I through VI, and will include other buildings which have specific appendages located where they may fall onto pedestrians or occupants of adjacent buildings. Residential buildings with less than six units are not included in this portion of the program, but the total number of buildings involved may exceed 1000, as estimated by the staff.

The priority system for reporting on external hazards is based on two separate criterion. Three zones of pedestrian density will be established in all the non-single family areas of the City. These zones will contain different levels of pedestrian use and will be based on actual counts of the number of people traversing the sidewalk along a building face at three separate times of day during a normal work week. This will provide a measure of the

potential number of pedestrians exposed to risk from falling objects. The second criteria is a rating system for each building in each zone. This point system is weighted to give greatest priority to appendages which could fall onto primary pedestrian access areas. A total points assessment, based on the location and quantity of external hazards present, will specify the time in which an owner must submit a report. This system will insure that buildings with the greatest number of appendages in the highest hazard locations are reported on first.

Engineering Reports

All engineering reports are required to be prepared by licensed civil or structural engineers and will contain information from on-site investigation, review of available design documents, and testing. These reports will include an identification of the potential hazards, an assessment of their level of deficiency, and methods for correcting them. The reference standard for the recommended repair methods must meet the criterion established in the following documents:

1) For unreinforced masonry buildings the latest edition of Division 88 Chapter IX of the City of Los Angeles municipal code.

2) For all other buildings and for external hazards the 1973 edition of the Uniform Building Code.

Other Requirements

To assist staff in determining compliance with the ordinance, the Committee recommends that a review board of structural engineers be established. This should assure that the quality and necessary content of these reports are comparable and that they are adequately prepared. The Committee also recommends that owners of buildings falling into the scope of this ordinance notify all their tenants that a report has been prepared and is on file in the Building Division offices. This information will allow tenants to become aware of their building's condition and make informed decisions concerning their choice of location. The Committee rejected the idea of any reference to future action requiring mandatory repair of buildings and specifically disapproved a motion to include in the ordinance, periodic reporting by the Building Official to the Council on the situation revealed by these reports and the extent of voluntary repair work accomplished.

NEGATIVE IMPACTS

Financial/Economic

Financial concerns were the most widely debated issues in considering the negative impacts of reducing seismic hazards. Repair costs for typical unreinforced masonry buildings in Los Angeles, ranged from $12.00 to $20.00 per square foot. Costs to repair other buildings to the 1973 UBC standards were unknown. It was decided by the Committee that requiring only an engineering investigation was an excellent method of mitigating the impact of costs to owners, while still obtaining valuable information. Nonetheless, the Committee wanted to estimate the costs to owners for hiring an engineer to prepare the reports. The cost will vary widely depending on the availability of original drawings and access to structural components, but should lie inside the following ranges:

Small or Medium size buildings:
75¢ to $1.50 per sq. ft.

Large buildings exceeding 40,000 sq. ft.:
25¢ to 75¢ per sq. ft.

The Committee believes that these costs, though small compared to potential repair costs, are significant and will create a financial hardship on some owners.

An indirect economic impact that this ordinance will have on buildings found to be seriously deficient will be a potential reduction of its market value which could further affect its sale or refinancing.

A final financial impact addresses the potential for difficulty in maintaining current levels of insurance coverage without increased costs when a report reveals hazardous conditions.

Disruption

A certain level of disruption of building tenants should be anticipated due to the nature of the investigation and testing which may be needed to prepare a complete report. This disruption should be short term and in some cases unnecessary where the structural components are exposed to clear view. Availability of original drawings will also affect the nature and extent of disruption.

Historical/Architectural

Owners of historic or architecturally significant buildings face a duel dilemma of having buildings of the era prior to required earthquake standards, which are desirable to preserve, but very costly to do so, if earthquake forces are to be addressed. The disclosure of significant deficiencies in the structural integrity of any of these buildings could result in their sale and possible demolition by a new owner for new construction on its site. Owners with seriously deficient building appendages, may choose to remove architectural appendages, significant to the character of the building, rather than pay for their proper anchorage.

Legal

The final impact is one that has been discussed by the Committee since its first meeting. It is a concern for the legal liability owners may incur when advised of the condition of their building and no action is taken to correct the deficiencies, particularly if an earthquake does occur and occupants or pedestrians are injured.

MITIGATION MEASURES

Two types of measures were recommended by the Committee to serve separate kinds of impacts involved in seismic hazard reduction. One set addresses the financial and historic building impacts and the other addresses a purely educational and training aspect.

The magnitude of the costs involved in preparing the required reports may pose a significant hardship on many building owners. The Committee strongly recommends a City program to provide low interest loans to owners who would suffer a hardship in obtaining financing to pay for these reports. Tax exempt bond sale revenue or compensating balance interest rate buy down methods could be used to implement this measure.

This Committee desired a mechanism to mitigate the potential impacts to historic buildings and its primary focus was on the density transfer concept. The Committee recommends that the City adopt a program allowing the sale of air rights or density transfer prior to enactment of this ordinance, in order to provide economic incentive for the preservation of existing historic or architecturally significant buildings, whose existence may be threatened by the ordinance.

The Committee was concerned from the start of its discussions about the overall affects that a major earthquake would have on this community. This concern led to a two part recommendation for mitigating the affects of an earthquake on the residents and workers in Palo Alto that looks beyond the hazards posed by

buildings. The Committee recommends: 1) The City develop and promote an educational campaign to inform homeowners and business owners in Palo Alto of the proper actions to take during, and after an earthquake, and; 2) The City develop an emergency plan focused on an earthquake disaster and hold regularly scheduled City-wide drills on this plan.

CONCLUSION

The Committee unanimously approved at its final meeting the content of the attached ordinance and recommends its adoption by the Council. The mitigation measures are an integral part of this recommendation and are believed by the Committee to be the minimum level of action by the City necessary to gain community support for this program and provide a fair and effective method of seismic hazard reduction.

Respectfully submitted,

John Northway

John Northway, Chairman
Seismic Hazard Committee

Attachments:
- Proposed Ordinance
- Negative Impacts
- Recommended Mitigation Measures
- Issues Discussed by Committee

<u>MITIGATION MEASURES</u>
<u>RECOMMENDED BY SEISMIC COMMITTEE</u>

1. The City should provide a program of low interest loans to owners required to submit an Engineering Report where the costs of such a report would create a hardship. [<u>Approved</u> by 9 to 2 vote]

2. The City should adopt a program allowing the sale of "air rights" or promoting the "density transfer concept" <u>prior</u> to enactment of this ordinance in order to mitigate the loss of historic buildings currently existing on underdeveloped sites. [<u>Approved</u> by 7 to 4 vote]

3. The City should develop and promote an educational campaign directed towards homeowners and business owners on the proper measures to take in the event of a major earthquake and the type of preparations individuals should make prior to such an event. [<u>Approved</u> unanimously]

4. The City should develop an emergency plan focused on an earthquake disaster and hold regular City-wide drills on this plan. [<u>Approved</u> unanimously]

Exhibit 6

Palo Alto Ordinance

Code Chapter 16.42

Seismic Hazards Identification Program

EXHIBIT 6

Palo Alto Ordinance: Code Chapter 16.42--Seismic Hazards Identification Program

Chapter 16.42

SEISMIC HAZARDS IDENTIFICATION PROGRAM

Sections:

16.42.010 **Purpose.** It is found and declared that in the event of a strong or moderate local earthquake, loss of life or serious injury may result from damage to or collapse of buildings in Palo Alto. It is generally acknowledged that Palo Alto will experience earthquakes in the future due to its proximity to both the San Andreas and Hayward faults. The purpose of this chapter is to promote public safety by identifying those buildings in Palo Alto which exhibit structural deficiencies and by accurately determining the severity and extent of those deficiencies in relation to their potential for causing loss of life or injury. The city council finds it desirable to identify the hazards that these deficiencies may pose to occupants of buildings and pedestrians in the event of an earthquake. Such a seismic hazards identification program is consistent with California Health and Safety Code Sections 19160-19169 and is necessary to implement the Palo Alto Comprehensive Plan's Environmental Resources Policy 14, Program 47. (Ord. 3666 § 1 (part), 1986).

16.42.020 Definitions. (a) "Bearing wall" means any wall supporting a floor or roof where the total superimposed load exceeds one hundred pounds per linear foot, or any unreinforced masonry wall supporting its own weight when over six feet in height.

(b) "Building," for the purpose of determining occupant load, means any contiguous or interconnected structure; for purposes of engineering evaluation, means the entire structure or a portion thereof which will respond to seismic forces as a unit.

(c) "Capacity for transfer" means the maximum allowable capacity of a structural system or connection to resist in a ductile manner the lateral forces it would encounter due to earthquake forces.

(d) "Civil engineer or structural engineer" means a licensed civil or structural engineer registered by the State of California pursuant to the rules and regulations of Title 16, Chapter 5 of the California Administrative Code.

(e) "External hazard" means an object attached to or forming the

exterior facade of a building which may fall onto pedestrians or occupants of adjacent buildings. Examples of this type of hazard include, but are not limited to, the following:

(1) Nonstructural exterior wall panels, such as masonry infill or decorative precast concrete;

(2) Parapets;

(3) Marquees, awnings or other roof-like projections from a building:

(4) Masonry or stone wall veneer and wall ornamentation, including cornices or other decorative appendages;

(5) Masonry chimneys;

(6) Tile roofing;

(7) Wall signs and exterior lighting fixtures hung from a building exterior;

(8) Fire escapes or balconies.

(f) "Geometry" means a building's shape or configuration, including setbacks of wall/column lines, reentrant corners, discontinuities in vertical and horizontal lateral force diaphragms, open storefront and building stiffness variations due to the distribution of resisting elements or the use of materials of differing properties within the same structural element, or other irregularities in plan or elevation.

(g) "Occupants" means the total occupant load of a building determined by Table 33-A of the 1973 Uniform Building Code, or the actual maximum number of occupants in that building if that number is less than seventy-five percent of the number determined by using Table 33-A. The number of actual occupants may be documented by counting actual seating capacity if permanent seating is provided in the occupancy, or by employee and client counts which can be substantiated as a practical maximum use of the space in the building. The chief building official will establish the procedure for documenting occupant loads.

(h) "Solution" means any justifiable method that will provide for the transfer of lateral forces through a system or connection to a degree which will substantially eliminate a potential collapse failure. A general description of the methods and materials to be used shall be included in sufficient detail to allow for a cost estimate of the solution to be made (i.e., adding shear walls, overlaying horizontal diaphragms, strengthening critical connections, etc.).

(i) "Unreinforced masonry (URM)" building means any building containing walls constructed wholly or partially with any of the following materials:

(1) Unreinforced brick masonry;

(2) Unreinforced concrete masonry;

(3) Hollow clay tile;

(4) Adobe or unburned clay masonry. (Ord. 3666 § 1 (part), 1986).

16.42.030 Scope of program. (a) Applicability. The following buildings in Palo Alto shall be required to have an engineering report submitted to the city's building inspection division, pursuant to Section 16.42.050, to determine: (i) the existence, nature and extent of structural deficiencies which could result in collapse or partial collapse of the building; and (ii) the existence, nature and extent of deficiencies in the anchoring of external hazards:

(1) Buildings constructed of unreinforced masonry (URM), except those of less than one thousand nine hundred square feet containing six or fewer occupants:

(2) Buildings constructed prior to January 1, 1935 containing one hundred or more occupants:

(3) Buildings constructed prior to August 1, 1976 containing three hundred or more occupants.

(b) Exemptions. The following buildings need not comply with this chapter:

(1) Buildings which have been structurally upgraded in substantial accordance with either the Los Angeles Division 88 Standard for URM buildings or the 1973, or later, edition of the Uniform Building Code;

(2) Buildings whose uses are subject to amortization under this code: provided that, upon the termination of the nonconforming use, such a building shall be required to be rehabilitated to the then current lateral force requirements in the Uniform Building Code prior to occupancy by a conforming use. (Ord. 3666 § 1 (part), 1986).

16.42.040 Building categories and implementation schedule. (a) Building Categories. The categories of buildings within the scope of this chapter are set forth in Table A, below.

(b) Owner Notification. The owners of buildings in categories I through III, except those designated as historic buildings, shall be notified within six months of enactment of the ordinance codified in this chapter by the building inspection division of the city of Palo Alto that their buildings are required to have an engineering report submitted to the city. Owners of designated historic buildings, as defined in Chapter 16.49, shall be notified within eighteen months of enactment of this ordinance.

(c) Implementation Schedule. The owners of buildings in categories I through III must submit engineering reports within the time frame set out in Table A, below, from the date of mailed notice by the city.

TABLE A

CATEGORY	DESCRIPTION	ENGINEERING REPORT SUBMITTED WITHIN DATE OF MAILED NOTICE (IN YEARS)
I	All URM buildings.	1 1/2
II	All pre-1935 buildings other than URM with 100 occupants or more.	2
III	All buildings with 300 occupants or more constructed between January 1, 1935 and August 1976.	2 1/2

(Ord. 3666 § 1 (part), 1986).

16.42.050 Engineering reports. (a) Preparation of Reports. Building owners shall employ a civil or structural engineer to prepare the investigation and engineering report outlined below.

(b) Purpose. To investigate, in a thorough and unambiguous fashion, a building's structural systems that resist the forces imposed by earthquakes and to determine if any individual portion or combination of these systems is inadequate to prevent a structural failure (collapse or partial collapse).

(c) General. Each building shall be treated as an individual case without prejudice or comparison to similar type or age buildings which may have greater or lesser earthquake resistance. Generalities or stereotypes are to be avoided in the evaluation process by focusing on the specifics of the structural system of the building in question and the local geology of the land on which the building is constructed.

(d) Level of Investigation. Some buildings will require extensive testing and field investigation to uncover potential structural deficiencies, while others will allow the same level of overall evaluation by a less complicated process due to simplicity of design or the availability of original or subsequent alteration design and construction documents.

It is the responsibility of the engineer performing the evaluation to choose the appropriate level of investigation which will produce a report that is complete and can serve as a sound basis for a conclusion on the collapse hazard the building may present.

(e) Format for the Report. The following is a basic outline of the format each engineering report should follow. This outline is not to be

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(2) Buildings whose uses are subject to amortization under this code: provided that, upon the termination of the nonconforming use, such a building shall be required to be rehabilitated to the then current lateral force requirements in the Uniform Building Code prior to occupancy by a conforming use. (Ord. 3666 § 1 (part), 1986).

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(b) Purpose. To investigate, in a thorough and unambiguous fashion, a building's structural systems that resist the forces imposed by earthquakes and to determine if any individual portion or combination of these systems is inadequate to prevent a structural failure (collapse or partial collapse).

(c) General. Each building shall be treated as an individual case without prejudice or comparison to similar type or age buildings which may have greater or lesser earthquake resistance. Generalities or stereotypes are to be avoided in the evaluation process by focusing on the specifics of the structural system of the building in question and the local geology of the land on which the building is constructed.

(d) Level of Investigation. Some buildings will require extensive testing and field investigation to uncover potential structural deficiencies, while others will allow the same level of overall evaluation by a less complicated process due to simplicity of design or the availability of original or subsequent alteration design and construction documents.

It is the responsibility of the engineer performing the evaluation to choose the appropriate level of investigation which will produce a report that is complete and can serve as a sound basis for a conclusion on the collapse hazard the building may present.

(e) Format for the Report. The following is a basic outline of the format each engineering report should follow. This outline is not to be

construed to be a constraint on the professional preparing the report, but rather to provide a skeleton framework within which individual approaches to assembling the information required by the ordinance may be accomplished. It also will serve as a means for the city to evaluate the completeness of each report.

(1) General Information. A description of the building including: (i) the street address: (ii) the type of occupancy use within the building, with separate uses that generate different occupant loads indicated on a plan showing the square footage of each different use; (iii) plans and elevations showing the location, type and extent of lateral force resisting elements in the building (both horizontal and vertical elements); (iv) a description of the construction materials used in the structural elements and information regarding their present condition; (v) the date of original construction, if known, and the date, if known, of any subsequent additions or substantial structural alterations of the building; and (vi) the name and address of the original designer and contractor, if known, and the name and address of the designer and contractor, if known, for any subsequent additions or substantial structural alterations.

(2) Investigation and Evaluation of Structural Systems. All items to be investigated and the methods of investigation for each type of building under consideration are contained in Appendices A and B, available from the city's building inspection division.

(3) Test Reports. All field and laboratory test results shall be included in the report. Evaluation of the significance of these test results shall be made with regard to each structural system or typical connection being evaluated. This evaluation may be limited to a statement of the adequacy or inadequacy of the system or connection based on the lateral load demand it would be required to resist by calculation. If tests reveal inadequacy, a conceptual solution must be included in the report.

(4) Conclusions. Based on the demand/capacity ratio and the specific evaluation items contained in Appendices A or B attached to the ordinance codified in this chapter, a statement shall be provided explaining the overall significance of the deficiencies found to exist in the building's lateral force resisting system regarding potential collapse or partial collapse failure.

(5) Recommendations. An appropriate solution, which could be used to strengthen the structure to alleviate any collapse or partial collapse threat, shall be specified.

(f) Exceptions and Alternatives. Exceptions to the specific items required to be included in an engineering report may be granted by the chief building official upon review of a written request from the engineer preparing the report. Such a request shall provide evidence that adequate information concerning the required item(s) can be determined by alternate means or that a conclusion can be made about the item without following the solution called for in the appropriate appendix. The purpose of granting such exceptions shall be to reduce the costs or disruption that would result

from taking required actions, when it can be shown that they are unnecessary to provide information available by other equivalent means. In no case will an exception be granted which would result in an item not being completely evaluated. The decision of the chief building official in granting exceptions is final. (Ord. 3666 § 1 (part), 1986).

16.42.060 **Review of reports.** (a) The city shall utilize the services of civil or structural engineers to assist the building inspection division in determining if the submitted engineering reports conform to the requirements of this chapter.

(b) The cost of this review shall be recovered by a fee assessed from the building owner based on the time required for the review. This fee amount shall be deducted from the plan checking fee collected for any future construction work that deals directly with correcting any of the structural inadequacies specified in the engineering report.

(c) Copies of the engineering reports shall be available to interested individuals for a standard copying fee or may be reviewed at the building inspection division offices. (Ord. 3666 § 1 (part), 1986).

16.42.070 **Responsibilities of the building owners.** (a) Notification of Building Tenants. A building owner shall notify all tenants, in writing, that a structural investigation has been performed and that the report is available at the building inspection division offices. This notice must be sent within thirty days of the date the report is submitted to the city.

(b) Letter of Intent. A building owner shall submit a letter to the building inspection division within one year of the date the engineering report was submitted, indicating the owner's intentions for dealing with the potential collapse hazards found to exist in the building. (Ord. 3666 § 1 (part), 1986).

16.42.080 Program status reports to the City Council. The chief building official shall submit a semiannual report to the city council on the status of the seismic hazards identification program. The reports shall include information regarding the number of buildings analyzed, the severity of the structural inadequacies discovered and any actions taken by individual building owners to correct these inadequacies. (Ord. 3666 § 1 (part), 1986).

16.42.090 Remedies. It shall be unlawful for the owner of a building identified as being included in the scope of this chapter to fail to submit a report on either building collapse hazards or external hazards within the time period specified in Section 16.42.040(c), Table A, or to fail to submit a letter of intent within the time period specified in Section 16.42.070(b). The following remedies are available to the city:

(a) The city may seek injunctive relief on behalf of the public to enjoin a building owner's violation of this chapter.

(b) A building owner violating this chapter shall be guilty of a misdemeanor and, upon conviction thereof, shall be punishable by a fine of not more than five hundred dollars or by imprisonment in the Santa Clara County Jail for a term not exceeding six months, or by both such fine and imprisonment. Such building owner is guilty of a separate offense for each and every day during any portion of which such violation of this chapter is committed, continued or permitted by such building owner.

(c) These remedies are not exclusive. (Ord. 3666 § 1 (part), 1986).

APPENDIX A

Procedures for Investigation of All Buildings (Except Unreinforced Masonry Bearing Wall Types)

(a) Preliminary Field Survey. Provide drawings of the building in plan, elevation and section sufficiently detailed to reveal the correct dimensions of the spans and extent of all structural elements in the building, including openings in walls and changes in framing directions or other data which will be used to evaluate the building.

(b) Areas of Special Investigation.

(1) Specify the type of roof diaphragm used in the building and its capacity for transfer of lateral forces.

(2) If the building is multi-story specify the existing floor diaphragm at each level above the foundation and give its capacity for transfer of lateral forces.

(3) Specify the types and spacing of connections used at each level to transfer the forces of the horizontal diaphragms into the vertical shear resisting elements of the structure, and the capacity for transfer of each type of connection present in the building.

(4) Specify the type of vertical structural elements which resist lateral forces and their individual capacities as determined either by testing or use of standard values for the types of construction found in the vertical elements.

(5) Specify the type and spacing of connections used to connect vertical shear resisting elements to each other and to the building foundation, and the capacity for transfer of each type of connection present.

(6) Specify the type of foundation system used and note any evidence of settlement.

(7) Specify the type of connection used to attach wall appendages or pre-cast wall elements to the structural frame.

Standards for the Analysis and Evaluation of All Buildings (Except Unreinforced Masonry Bearing Wall Types)

(a) Purpose. The objective of these investigations is to identify and quantify the structural inadequacies that may be present in a building which

could lead to a collapse or partial collapse during an earthquake. The focus of the reports should be 1) determining the potential life safety threat that the building presents to its occupants and 2) the potential threat to pedestrians or occupants of adjacent buildings from falling external hazards.

(b) Capacity vs Demand of the Existing Structural System and Its Elements.

(1) Define the overall type of lateral force resisting system used in the building based on Table 23-I of the 1973 Uniform Building Code. If the building has a dual or hybrid system, describe the systems and explain how they function both in combination and separately to justify the "K" factor to be choosen.

(2) For each type of diaphragm, shear wall, moment frame, braced frame and interconnection of lateral force resisting systems provide an analysis of the loads (demand) which these elements would be subject to based on the design parameters set forth in the 1973 edition of the Uniform Building Code.

(3) For each type of diaphragm, shear wall, frame and interconnection of lateral force resisting system determine a maximum capacity based on currently accepted or published allowable values, adjusted as appropriate for the material involved when used to resist earthquake forces.

(4) Provide a ratio of capacity to demand for each system or interconnection evaluated in (2) and (3) above and provide a statement of the significance of this ratio, regarding the potential for failures which could lead to a collapse, considering the materials used and the type of lateral force resisting system present.

(c) Specific Evaluation Items. The report shall contain a statement regarding the significance of each item in this section which is found to occur in the building.

(1) General.

A. Assess the condition of the structure, the quality of workmanship, the level of maintenance and the type of construction with regard to the potential loss of strength in the structural systems due to decay or deterioration.

B. Assess the redundancy exhibited in the structural system and the reserve capacity that elements of the system may provide.

C. Assess the presence or lack of ductility in the lateral force resisting elements and ductility differences due to the use of dissimilar materials in the horizontal and vertical diaphragms.

D. Assess how adequately the building is tied together in an overall sense to allow the lateral force resisting systems an opportunity to receive the forces they are designed to resist.

(2) Geometry.

A. Consider how and where torsional (rotation) forces, induced by the eccentricity of the building center of mass to its center of rigidity, are taken into the lateral force resisting system and identify the individual elements which will transmit these additional forces. Assess the potential capacity these elements have to resist the additional loads from this source.

B. Consider the effects of discontinuities in the lateral force resisting systems with regard to the existence of adequate ties, boundary members, chords or drag struts, etc. to allow redistribution of forces. Assess the capacity of the systems or elements which would receive the redistributed forces if adequate ties exist.

C. Consider the effects of reentrant corners (including the shape of individual columns) and assess their contribution to the response of the building at locations where they occur.

(3) Building Separation.

A. Consider the effects of adjoining buildings, which may have different vibration periods resulting in non-synchronized movement of the adjacent exterior walls, placing out of plane impact forces on these walls.

B. Assess the level of drift control, particularly at open storefronts and the actual physical separation distance between the exterior walls of the building and ajoining building walls.

C. Assess conditions where the wall of a building on one property provides support for structural elements of the adjoining property's building.

(4) Non-Ductile Reinforced Concrete Frames.

A. Consider non-ductile frames which act alone without the benefit of shear walls or braced frames.

B. Assess the level of compression or shear forces due to existing vertical loads on the critical supporting elements of the frame.

C. Assess masonry infill walls between frame members and their effect on the forces a column/beam joint will be subjected to when attempting to transmit lateral forces into these walls.

(5) Precast Concrete Connections

A. Assess the effects of temperature creep and shrinkage of concrete surrounding welded insert connections to precast systems and elements.

B. Consider the potential brittle failure of such connections.

(6) Non-Structural Elements.

A. Assess the effect that partitions, infill walls, precast concrete exterior (architectural) elements and ceiling systems. which have considerable strength and stiffness characteristics, may have on the overall response of the building.

B. Assess the effect of inadvertant bracing by non-structural elements such as infill walls, stair stringers or other situations of localized restraint on columns.

C. Assess the potential stress concentrations at the unrestrained ends of columns which may result from partial restraint or bracing of columns.

(7) Site Geology.

A. Consider the maximum ground shaking intensity for the building site and liquefaction potential or susceptibility by using available earthquake hazard maps.

B. Assess any existing site specific geology/soils reports to gauge the effects that the local conditions may have on the overall response of the building.

APPENDIX B

Procedures for Investigation of Unreinforced Masonry Bearing Wall Buildings

(a) Preliminary Field Survey. Prepare framing plans for roof and floors noting all beams, trusses or major lintels of all URM piers or pilasters. Prepare elevations of all URM walls noting all openings in the walls and any discontinuities above the building base.

(b) Special investigations of the following nature must be made:

(1) Note all parts of the vertical load carrying system that may act as ties to lateral load-resisting elements, to determine the elements or systems that may control relative displacements between the building's base, floors and roof.

(2) Note on floor plans all interior crosswalls that are continuous between floors or floor and roof, even if the connection of such walls to the floor or roof is only by finishes.

(3) Draw the relationship of roof or floor framing and ceiling framing to determine the extent and method if any, of their inter-connection.

(4) Draw the support systems for URM walls that are not continuous to the building base noting the materials used to provide that support. (i.e., steel frame, concrete frame, etc.)

(5) Draw on floor and roof plans the extent of sheathing and finish materials and describe their nature and nailing pattern. Note any difference in materials used which could lead to substantial variations in diaphragm stiffness. Openings in floors or roofs adjacent to URM walls must be noted. Note the type of roofing system currently in place and note if this roofing is applied directly to the main roof deck or if there are locations where it is on a cricket or other superimposed deck.

(c) Investigation of current anchorage of URM walls to floors and roof. Show the location of all wall anchors on the floor/roof plans and specify their spacing, size, and method of connection. Details of the existing anchorage system should be prepared. Embedded portions of anchors must be exposed to determine this level of detail. A minimum of 2 percent or 2 anchors exposed per floor or roof level should establish average conditions.

(d) Investigation of existing URM walls. Investigate the following items if they occur in the building, and determine:

(1) The thickness of URM walls at all levels and location of any changes in thickness.

(2) The materials used for lintels and masonry arches and their bearing area on columns or piers.

(3) The materials used in columns or piers supporting lintel beams or arches.

(4) The height of parapets, cornices, and gable ends of URM walls above the uppermost existing anchorages.

(5) The anchorage or bonding of terra cotta, cast-stone or similar facing to the back up wythes of brickwork at cornices and other architectural appendages.

(6) The coursing of exterior wythes of masonry, the bonding of wythes of masonry, and the materials used in each wythe.

(7) The condition of mortar joints and areas of lightly unburned brick should be noted on the wall elevations. Existing cracks in wall elements should also be noted.

(e) Testing. The testing of existing anchorage systems must be made to determine an average capacity. Testing shall be accomplished in accordance with the following requirements.

(1) Existing Wall Anchors of URM Buildings. Five (5) percent of existing rod anchors shall be tested in pullout by an approved testing laboratory. The minimum tested quantity shall be four (4) per floor or roof level, with two (2) tests at walls with framing perpendicular to the wall and two (2) at walls with framing parallel to the wall.

The test apparatus shall be supported on the masonry wall at a minimum distance of the wall thickness from the anchor tested. Where due to obstructions this is not possible, details of the condition encountered and the alternate method used must be included in the test result report, with calibration adjustment for conditions where the reaction of the test apparatus contributes to the tension value of the anchor.

The rod anchor shall be given a preload of 300 pounds prior to establishing a datum for recording elongation. The tension test load reported shall be recorded at 1/8" relative movement of the anchor to the adjacent masonry wall surface.

The testing of existing URM walls to determine the allowable bed-joint shear is required in accordance with the following requirements.

(2) In Place Shear Tests of Brick Masonry. The bed joints of the outer wythe of the masonry shall be tested in shear by laterally displacing a single brick relative to the adjacent bricks in that wythe. The opposite head joint of the brick to be tested shall be removed and cleaned prior to testing. Steel bearing plates of the full dimension of the brick shall be inserted at

each end of the test jack. The bearing plates shall not contact the mortar joint. The minimum quality mortar in 80 percent of the shear tests shall not be less than the total of 30 psi when reduced to an equivalent zero axial stress. The shear stress shall be based on the gross area of both bed joints and shall be that at which movement of the adjacent brick is first observed.

The minimum quantity of tests shall be two (2) per wall or line of wall elements resisting a common force (i.e., per story) or one (1) per 1500 square feet of total URM wall surface, with a minimum of 8 tests for any building. The tests should be conducted at least two brick courses above or below the bond course and be distributed vertically to include a variety of dead load surcharge situations. The exact test location shall be determined at the building site by the engineer responsible for the investigation and the distribution of such tests must be approved by the building official prior to actual testing. In single story buildings, the wall above the lintel beam at an open storefront need not be tested.

Standards for the Analysis and Evaluation of Unreinforced Masonry Bearing Wall Buildings

(a) Analysis

(1) General

The total lateral seismic forces should be computed in accordance with the following equation:

$$V = ZIKCSW$$

The value of KCS need not exceed the value set forth in Table B1-1. The value of Z and I shall be equal to 1.0. The value of W shall be as set forth in the Uniform Building Code.

(2) Lateral Forces on Elements of Structures.

Parts or portions of buildings and structures shall be analyzed for lateral loads in accordance with Chapter 23 of the UBC but not less than the value from the following equation:

$$F_p = IC_pSW_p$$

For the provisions of this section, the product of IS need not exceed 1.0. The value of C_p and W_p shall be as set forth in the UBC.

Exception: Unreinforced masonry walls may be analyzed in accordance with Section (b).

(3) The elements of buildings required to be analyzed shall include the following:

Wall height to thickness ratio.
Tension bolts for bending.
In-plane shear forces.
Parapets.
Diaphragm stress and diaphragm chords at floors and roof.

(4) Anchorage and Interconnection.

Anchorage and interconnection of all parts, portions and elements of the structure shall be analyzed for lateral forces in accordance with the UBC and the formula in Subsection (2) above. Masonry walls shall be anchored to all floors or roof to resist a minimum of 200 pounds per linear foot acting normal to the wall at the level of the floor or roof or will be considered inadequate.

(5) Required Analysis.

Except as modified herein, the analysis and recommended structural alteration of the structure shall be in accordance with the analysis specified in the UBC. A complete, continuous load path from every part or portion of the structure to the ground shall be shown to exist for required lateral forces. All parts, portions or elements of the structure shall be shown to be interconnected by positive means.

(6) Analysis Procedure.

Stresses in materials and existing construction utilized to transfer seismic forces from the ground to parts or portions of the structure shall conform to those permitted by the UBC and those types of materials of construction specified under the Materials of Construction Section (b). In addition to the seismic forces required, unreinforced masonry walls shall be analyzed as specified in the UBC to withstand all vertical loads. When calculating shear or diagonal tension stresses due to seismic forces, existing masonry shear walls may be allowed to resist 1.0 times the required forces in lieu of the 1.5 factor required by the UBC. No allowable tension stress will be permitted in unreinforced masonry walls. Walls not capable of resisting the required design forces specified in this appendix shall be deemed inadequate.

Exception: Unreinforced masonry walls which carry no design loads other than their own weight may be considered as veneer if they are adequately anchored to elements which are not part of the existing lateral force resisting system.

(7) Existing materials.

When stress in existing lateral force resisting elements are due to a combination of dead loads plus live loads plus seismic loads, the allowable working stress specified in the UBC may be increased 100 percent. However, no increase will be permitted in the stresses allowed in Section (b). The stresses in members due only to seismic and dead loads shall not exceed the values permitted in the UBC.

(8) Allowable reduction of bending stress by vertical load.

Calculated tensile fiber stress may be reduced by the full direct stress due to vertical dead loads.

(b) Materials of Construction.

(1) General

All materials permitted by this code, including their appropriate allowable stresses and those existing configurations of materials specified herein, may be utilized to show adequacy of existing construction.

(2) Existing Materials.

Unreinforced masonry walls analyzed in accordance with this appendix may provide vertical support for roof and floor construction and resistance to lateral loads. The bonding of such walls shall be as specified in the UBC.

Tension stresses due to seismic forces acting normal to the wall may be neglected if the wall does not exceed the Height to Thickness ratio and the in-plane shear stresses due to seismic loads set forth in Table B1-2. If the Wall Height or Length to Thickness ratio exceeds the specified limits, the wall will be considered inadequate unless braced by vertical members designed to satisfy the requirements of the UBC. The deflection of such bracing members at design loads shall not exceed one-tenth of the wall thickness.

Exception: The wall may be supported by flexible vertical bracing members designed in accordance with this appendix if the deflection at design loads is not less than one quarter nor more than one third of the wall thickness.

All vertical bracing members shall be attached to floor and roof construction for the design loads independently of wall anchors. Horizontal spacing of vertical bracing members shall not exceed one-half the unsupported height of the wall or ten feet, whichever is less.

(3) Existing roof, floors, walls, footings and wood framing.

Existing materials, including wood shear walls may be used as part of the lateral load resisting system, provided that the stresses in these materials do not exceed the values shown in Table B1-3. Wood shear walls may be recommended to strengthen portions of the existing seismic resisting system.

(4) Minimum Acceptable Quality of Existing Unreinforced Masonry Walls.

All unreinforced masonry walls utilized to carry vertical loads and seismic forces parallel and perpendicular to the wall plane shall be tested as specified in Section (e) of the investigation portion of this appendix. All

masonry shall be of a quality not less than the minimum standards established or shall be considered inadequate. Pointing of mortar of all masonry wall joints may be performed prior to testing if joints are raked and cleaned to remove loose and deteriorated mortar. Mortar shall be Type S or N, except masonry cements shall not be used. All preparation and pointing shall be done under the continuous inspection of a special inspector, whose reports shall be included in the final report.

(5) Determination of Allowable Stresses for Design Methods Based on Test Results.

Design seismic in-plane shear stresses shall be related to test results in accordance with Table B1-4. Intermediate values between 3 and 10 psi may be interpolated.

Compression stresses for unreinforced masonry having a minimum design shear value of 3 psi shall not exceed 100 psi. Design tension values for unreinforced masonry shall not be permitted.

(6) Construction Details.

All unreinforced masonry walls shall be anchored at all floors and roof with tension bolts through the wall or by existing rod anchors at a maximum spacing of six feet. All existing rod anchors shall be secured to the joists to develop the required forces. Testing of the existing rod anchors shall be conducted according to Section (e) of the investigation portion of this appendix.

Diaphragm chord stresses of horizontal diaphragms shall be developed in existing materials or be considered inadequate.

Where trusses or beams other than rafters and joists are supported on masonry piers, these piers must be shown to provide adequate support during seismic loading.

Parapets and exterior wall appendages not capable of resisting the forces specified in this appendix shall be considered hazardous, and methods for proper anchorage must be developed.

TABLE B1-1
HORIZONTAL FORCE FACTORS BASED
ON OCCUPANT LOAD

OCCUPANT LOAD	KCS
Building with an occupant load greater than 100	0.133
All others	0.100

TABLE B1-2
ALLOWABLE VALUE OF HEIGHT-THICKNESS (h/t) RATIO
OF UNREINFORCED MASONRY WALLS WITH MINIMUM
QUALITY MORTAR

	BUILDINGS WITH COMPLYING CROSSWALLS	ALL OTHER BUILDINGS
Walls of one-story buildings	16	13
First-story wall of multistory buildings	16	15
Walls in top story of multistory buildings	14	9
All other walls	16	13

NOTES:

1. Minimum quality mortar shall be determined by laboratory testing in accordance with Section (e) of the investigation portion of this appendix.

2. The wall height may be measured vertically to bracing elements other than a floor or roof. Spacing of the bracing elements and wall anchors shall not exceed six feet.

3. Crosswalls are defined as interior walls of masonry or wood frame construction with surface finish of wood lath and plaster, 1/2" thick gypsum board, or solid horizontal wood sheathing. They may not exceed 40 feet horizontal separation, must be full story height with a minimum length of 1 1/2 times the story height and be continuous through all stories.

TABLE B1-3
VALUES FOR EXISTING MATERIALS[1]

1. Horizontal Diaphragms	
a. Roofs with straight sheathing with the roof covering applied directly to the sheathing.	100 pounds per foot for seismic shear
b. Roofs with diagonal sheathing with the roof covering applied directly to the sheathing.	400 pounds per foot for seismic shear
c. Floors with straight tongue and groove sheathing.	150 pounds per foot for seismic shear
d. Floors with straight sheathing and finished wood flooring.	300 pounds per foot for seismic shear
e. Floors with diagonal sheathing and finished wood flooring.	450 pounds per foot for seismic shear
f. Floors or roofs with straight sheathing and plaster applied to the values for items 1-a and 1-c joist or rafters.	Add 50 pounds per foot to the allowable
2. Shear Walls	
Wood stud walls with lath and plaster	100 pounds per foot each side for seismic shear
3. Plain Concrete Footings	f'_c = 1500 psi unless otherwise shown by tests
4. Douglas Fir Wood	Allowable stress same as No. 1 D.F.2
5. Reinforcing Steel	f'_c = 18,000 psi maximum[2]
6. Structural Steel	f'_c = 20,000 psi maximum[2]

[1] Material must be sound and in good condition.

[2] Stresses given may be increased for combinations of loads as specified in Subsection (b) of the analysis and evaluation portion of this appendix.

TABLE B1-4
ALLOWABLE SHEAR STRESS FOR TESTED
UNREINFORCED MASONRY WALLS

SHEAR TESTS	
Eighty percent of test results in psi not less than:	Seismic in-plane shear in psi based on gross area[1]
30 plus axial stress	3
40 plus axial stress	4
50 plus axial stress	5
100 plus axial stress or more	10 (maximum)

1 Allowable shear stress may be increased by addition of 10 percent of the axial stress due to the weight of the wall directly above.